



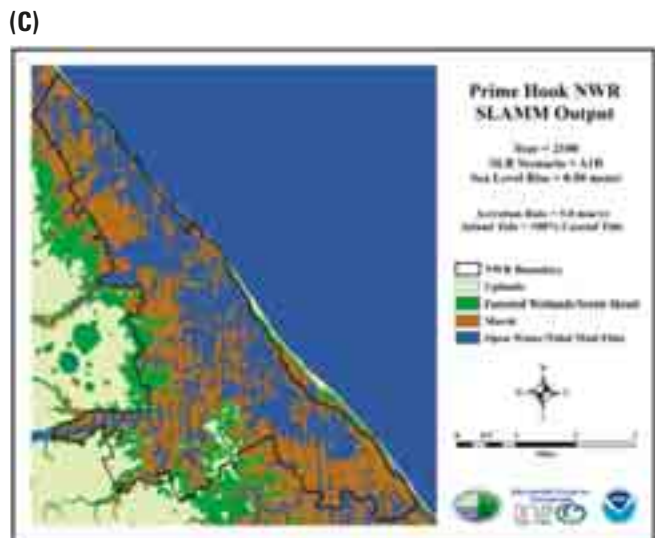
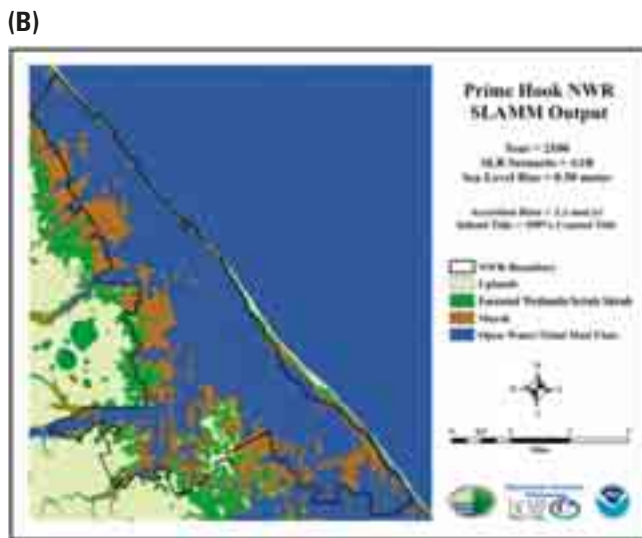
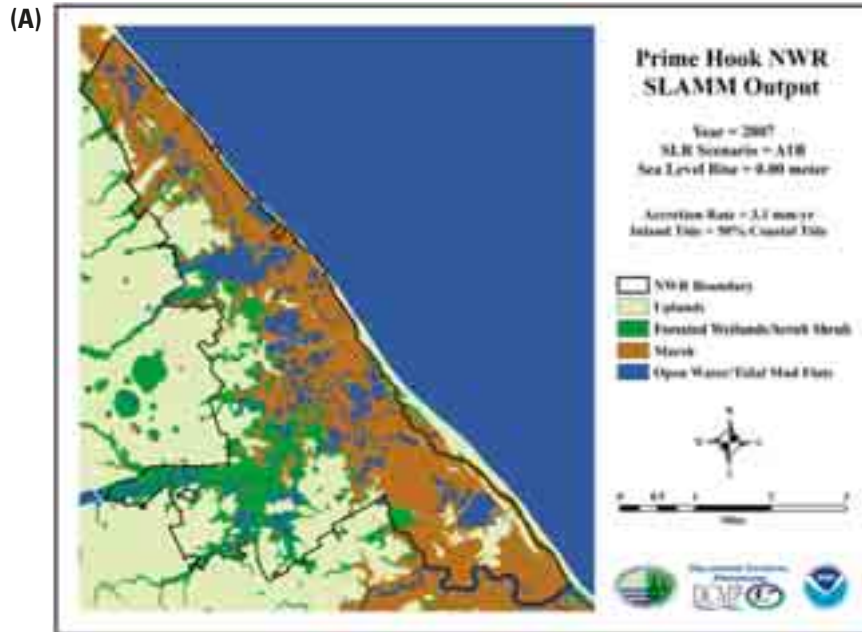
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Diamondback terrapin

The potential effects of sea level rise on refuge land cover have been modeled through the SLAMM effort described in chapter 2. The model was applied utilizing inputs representing a range of possible future scenarios. It is anticipated that the reality could fall anywhere within these predicted outcomes. As an example, if sea level rises as predicted by the A1B greenhouse gas emission scenario in the Special Report on Emissions Scenarios (IPCC 2000), the total sea level increase on the refuge would be 0.50 meters in 100 years. If the model assumes that salt marsh accretion keeps pace with current sea level rise rates and that there is full tidal influence along the coast, then the refuge is predicted to lose more than half of its marsh and the amount of open water and tidal mudflat (combined) will more than quadruple (figure 3-12). If the model assumes that salt marsh accretion will increase to 5.0 mm/yr, keeping pace with sea level rise as salt marshes often can, then the loss of marsh is small and conversion to open water and tidal mud flat are not as pronounced (figure 3-12). In both cases, more than half of the upland is predicted to be lost. The primary difference is whether or not the remaining areas are maintained in some form of wetland cover or are converted to open water, which may depend on marsh accretion processes. Under each sea level rise and marsh accretion scenario, if the model assumes that coastal dunes will instead be maintained, these predictions do not change appreciably. Results for additional scenarios, such as an increased rate of sea level rise, can be found in Scarborough (2009).

An updated version of SLAMM (6.0.1) is now available, but was not available at the time the analysis was completed for the refuge. Although modeling data should be considered with caution, as high levels of uncertainty and unforeseeable factors can significantly alter model output projections and habitat predictions for the future, the results of this modeling effort can give us a general sense of how climate change and sea level rise will likely affect refuge habitats in the future. The potential land cover changes predicted by the SLAMM modeling were considered in the development of the management objectives and strategies (chapter 4). However, these modeling results are certainly not the primary factor driving evaluations of shoreline and wetland management regimes on the refuge, as the refuge increasingly has current locally collected data to rely upon.

Figure 3-12. Selected SLAMM Output Maps from Scarborough 2009. (A) = Current (2007) land cover; (B) = 2100 Predicted land cover assuming 0.5 meters of sea level rise, marsh accretion keeping pace with current sea level rise (3.1 mm/yr), and full tidal influence.



The Cost of Infrastructure Rehab/Replacement:

To maintain Unit II as a freshwater system, it is anticipated that significant infrastructure rehabilitation or replacement would be necessary. A cost analysis included three factors: dune construction, water control structure redesign and replacement, and elevating two State roads, Fowler Beach Road and Prime Hook Road.

Dune Construction

No formal beach management plan has been developed for Prime Hook NWR beaches. However, we can use the data provided in the management plan for Delaware beaches completed in March 2010 to make some rough estimates. Table

3-12 provides estimates for design, permitting, construction, and monitoring of existing sand dunes within the neighboring communities of Slaughter Beach and Prime Hook Beach. Design scenarios and their associated costs are estimated based on the projected average return interval of storm events that result in a particular degree of severity and resulting storm damage. The State's analysis considered the dune design that would be required to withstand a 5 or a 10-year storm. For example, a 5-year storm is a severe storm that is expected to hit our area 1 year in 5. Another way of stating it is that there is a 20 percent chance that we will experience a 5-year storm in any given year. Similarly, one can expect a 10-year storm on average once every 10 years, or a 10 percent chance of having the storm in any 1 year. The actual number of years between storms of any given severity varies because of the naturally changing climate. It is possible to have more than one 5-year storm in a year. Therefore, beaches that endure damage from successive 5-year storms would require reconstruction on a more frequent basis. In addition to the 5 and 10-year scenario, the State has projected costs for strategic fill, i.e., fill placed along the specific locations of greatest need.

*American
oystercatcher*



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Table 3-12. Cost Estimates from DNREC Beach Management Plan Associated with Dunes within Slaughter Beach and Prime Hook Beach communities

Strategic Fill Placement	Prime Hook Beach					Slaughter Beach				
	Budget Estimate									
Project Element	FY10/11	FY11/12	FY12/13	FY13/14	Total	FY10/11	FY11/12	FY12/13	FY13/14	Total
*Geotechnical Investigation	\$45,193.00				\$45,193.00	\$139,802.00				\$139,802.00
*Design/Permitting	\$22,596.00				\$22,596.00	\$69,901.00				\$69,901.00
Construction				\$416,835.00	\$416,835.00				\$499,975.00	\$499,975.00
Env. Permit Monitoring				\$17,500.00	\$17,500.00				\$17,500.00	\$17,500.00
Beach Survey	\$8,000.00	\$8,000.00	\$8,000.00	\$8,000.00	\$36,000.00	\$16,000.00	\$16,000.00	\$16,000.00	\$16,000.00	\$64,000.00
Total	\$75,789.00	\$8,000.00	\$8,000.00	\$442,335.00	\$534,124.00	\$225,703.00	\$16,000.00	\$16,000.00	\$533,475.00	\$791,178.00
5 Year Scenario										
Project Element	FY10/11	FY11/12	FY12/13	FY13/14	Total	FY10/11	FY11/12	FY12/13	FY13/14	Total
*Geotechnical Investigation	\$45,193.00				\$45,193.00	\$139,802.00				\$139,802.00
*Design/Permitting	\$22,596.00				\$22,596.00	\$69,901.00				\$69,901.00
Construction				\$787,800.00	\$787,800.00				\$2,112,800.00	\$2,112,800.00
Env. Permit Monitoring				\$35,000.00	\$35,000.00				\$70,000.00	\$70,000.00
Beach Survey	\$8,000.00	\$8,000.00	\$8,000.00	\$8,000.00	\$36,000.00	\$16,000.00	\$16,000.00	\$16,000.00	\$16,000.00	\$64,000.00
Total	\$75,789.00	\$8,000.00	\$8,000.00	\$830,800.00	\$922,589.00	\$225,703.00	\$16,000.00	\$16,000.00	\$2,198,800.00	\$2,456,503.00
10 Year Scenario										
Project Element	FY10/11	FY11/12	FY12/13	FY13/14	Total	FY10/11	FY11/12	FY12/13	FY13/14	Total
*Geotechnical Investigation	\$45,193.00				\$45,193.00	\$139,802.00				\$139,802.00
*Design/Permitting	\$22,596.00				\$22,596.00	\$69,901.00				\$69,901.00
Construction				\$1,522,800.00	\$1,522,800.00				\$3,680,800.00	\$3,680,800.00
Env. Permit Monitoring				\$35,000.00	\$35,000.00				\$70,000.00	\$70,000.00
Beach Survey	\$8,000.00	\$8,000.00	\$8,000.00	\$8,000.00	\$36,000.00	\$16,000.00	\$16,000.00	\$16,000.00	\$16,000.00	\$64,000.00
Total	\$75,789.00	\$8,000.00	\$8,000.00	\$1,565,800.00	\$1,657,589.00	\$225,703.00	\$16,000.00	\$16,000.00	\$3,766,800.00	\$4,024,503.00

*Notes: The costs for these items are proportional to total volume placed for all of the seven communities included in this management plan

Renourishment costs based on restoring 60 percent of initial volume to restore historic losses; costs are based on work being performed on a regional basis; costs shown are in July 2009 prices.

The costs range from \$534,124 to \$1,657,589 for the three scenarios at Prime Hook beach, and from \$791,178 to \$4,024,503 at Slaughter Beach. We have no cost estimates at this time for dune construction along the overwashed portion of Unit II barrier beach. The combined linear footage of privately and refuge owned beach along Unit II, of which only 60 percent is refuge owned, is approximately 1.5 miles. The 5 and 10-year scenarios at Prime Hook Beach are to be conducted along nearly 1.5 miles of beach, as well. It would therefore be reasonable to expect that the costs of constructing a dune along Unit II would be comparable with the costs of dune construction at Prime Hook Beach.

There are, however, some very important differences between the Prime Hook and Unit II beaches. First, active beach management has been occurring at Prime Hook beach to some degree throughout the years. Prime Hook beach has an intact dune system that is currently elevated several feet above mean high water. Conversely, the Unit II barrier has largely succumbed to natural overwash events, leaving small isolated dunes. The berm typically overwashes over much of its length during storm events. Additionally, there are two active inlets, currently on private land, that receive at least some tidal flow during most high tide events. Therefore, we conclude that the cost of strategic placement of sand as listed for Prime Hook Beach is not a useful figure for comparison because strategic placement assumes supplementing an intact dune system. Since the existing berm along Unit II is barely above mean high water, a considerably larger quantity of sand, and a much higher cost, would be required to achieve the 5 or 10-year specifications considered adequate for Prime Hook Beach. The costs of dune construction on Unit II may approach the cost of construction for 2.7 miles of Slaughter Beach, or as high as \$4,000,000.

Table 3-13 summarizes the length of beach, quantity of sand required for initial fill, quantity of sand required in subsequent years, the return maintenance interval and cost of construction alone, without permitting, design, and monitoring costs. The maintenance intervals are 4, 5, and 10 years, respectively for strategic, 5-year and 10-year scenarios. Maintenance would be required more often if storm severity or frequency becomes more intense in the years after initial treatment.

Table 3-13. Summary of Material Requirements and Costs for Construction of Dunes According to DNREC Beach Management Plan

					Maintenance	Initial Constr.
	Berm Length	Berm Width	Berm Elev. (NAVD 88)	Initial Fill	Placement (Interval)	Cost Only
Prime Hook Beach						
Strategic	2,800'	20'	7.2'	24,000 cy	14,400 cy (4 years)	\$416,835.00
5 Year	7,500'	20'	7.2'	71,000 cy	36,600 cy (5 years)	\$787,800.00
10 Year	7,500'	55'	7.2'	176,000 cy	105,600 cy (10 years)	\$1,522,800.00
Slaughter Beach						
Strategic	2,500'	15'	7.5'	36,500 cy	21,900 cy (4 years)	\$499,975.00
5 Year	14,500'	15'	7.5'	252,500 cy	151,500 cy (5 years)	\$2,112,800.00
10 Year	14,500'	55'	7.5'	476,500 cy	285,900 (10 years)	\$3,680,800.00

Importantly, if the purpose of dune reconstruction is to provide an intact barrier to artificially maintain freshwater marshes, then constructing a berm with the assumption that it will be intact only in the face of a 5 or 10-year storm will not sustain a freshwater marsh system. Since freshwater marshes are very

vulnerable to rapid increases in salinity, a barrier system should be designed to withstand, at least, a 30-year storm, otherwise the marsh vegetation and obligate freshwater biota can be expected to die frequently. A berm of this magnitude, with accompanying periodic replenishment, will increase costs, not by a factor of three above the 10-year costs, but more geometrically, because the commensurate increase in sediment requires substantially more sand to be placed over a far broader footprint, as well as formed into a higher berm.

Water Control Structures

In addition to the dunes, the three water control structures are maintained to manage water levels within the impoundment. The replacement costs of the three water control structures and associated levees are listed in table 3-14.

Table 3-14. Replacement Costs of Refuge Water Control Structures

Water Control Structure/Levees	Estimated Cost
Prime Hook Creek WCS	\$436,000.00
Petersfield WCS	\$852,040.00
Petersfield West Dike	\$463,610.00
Petersfield East Dike	\$208,311.00
Fowler Beach WCS	\$1,033,725.00

Although the Prime Hook and Petersfield structures play a role in the Unit II water management, only the Fowler Beach water control structure is used for this analysis. The replacement of the structure would cost approximately \$1,033,725, but could cost more. Even if the structure is replaced, the refuge can only manage water levels to 2.8 feet mean sea level (msl), according to deed restrictions. But, mean sea level in 1981 is different from mean sea level today. The deed is recorded in Deed Book 1097, page 249. Currently, larger storm events have overtopped the existing structure, allowing water in excess of 2.8 feet msl to enter the impoundment. Rising sea levels, subsidence, and other factors make it unlikely that the refuge will be able to manage water levels in the future. Saltwater intrusion is inevitable at the water control structures as we lose control to the rising seas.

Further complicating our water management challenges is the fact that the water control structures are sitting at an elevation different from the original planned construction elevation. Although we do not know the exact post-construction elevations of the water control structures, we assume they were very close to the planned elevations. In 2010, the Delaware Coastal Program resurveyed our water control structures to determine their current elevation. Subsidence of both upland and the marshes in the Delaware region is extensive, but varies based on local conditions. The results (table 3-15) show that the water control structures are lower than their planned construction elevations by approximately 5.8 to 11.25 inches. This data further supports our assumption that we will lose water management capabilities in the near future. See appendix K for further details.

Table 3-15. Estimated Subsidence of Refuge Water Control Structures

Water Control Structure	Suspected subsidence (inches)
Prime Hook Creek WCS	11.25"
Petersfield WCS	10.07"
Fowler Beach WCS	5.83"

Integrity of Road Infrastructure:

There are three roads crossing the marsh to the barrier island, forming the dikes on the northern and southern borders of Units II and III. These roadways, built in the 1950s and 1960s at relatively low elevation, have sustained numerous tidal overwashes in recent years. In 2009, the State conducted elevation surveys of the roads for analysis. Figure 3-13, figure 3-14, and figure 3-15 illustrate the results of those surveys for Fowler Beach, Prime Hook, and Broadkill Roads, respectively. Road elevation has been plotted in relation to the local mean higher high water elevation (red line). For each road, significant portions of the road (blue line) lie below mean higher high water, suggesting that the roads may have subsided. These roads routinely flood during forecast NOAA coastal flood events. As sea levels and high tide events continue to increase, the ability of these roads to serve as dikes will be reduced.

Figure 3-13. Elevations along Fowler Beach Road in relation to MHHW along the segment depicted in red on the map

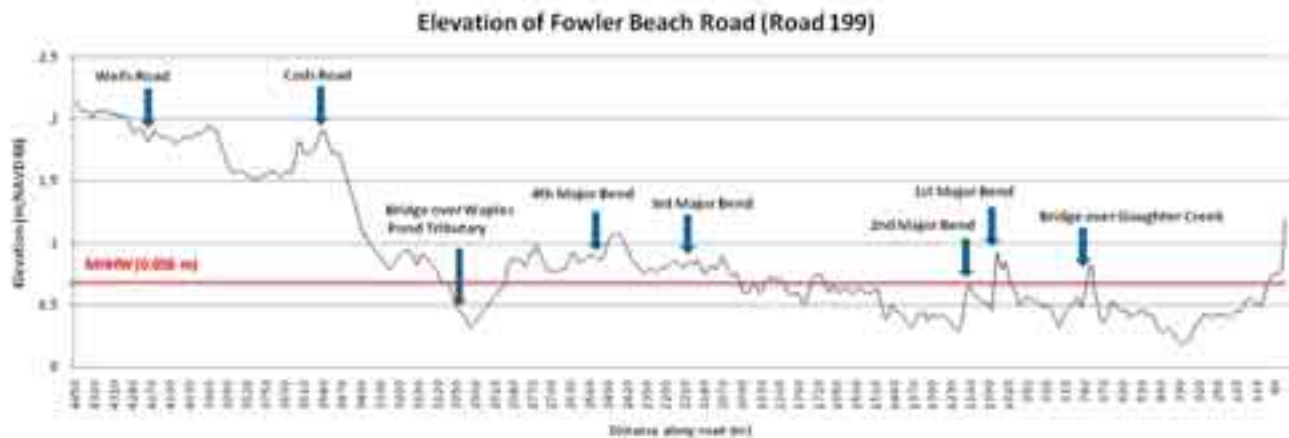
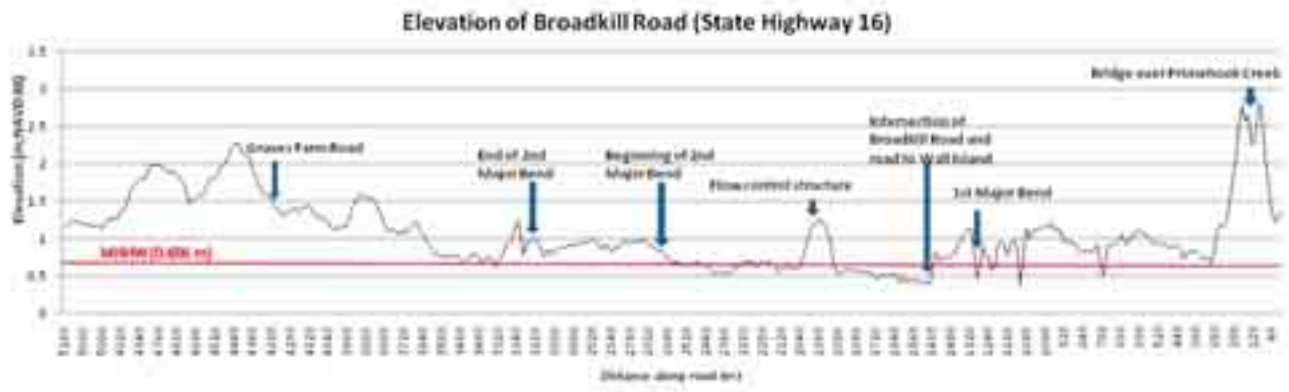


Figure 3-14. Elevations along Prime Hook Road in relation to MHHW along the segment depicted in red on the map



Figure 3-15. Elevations along Broadkill Beach Road in relation to MHHW along the segment depicted in red on the map



Delaware Department of Transportation (DelDOT) currently owns a 50-foot right-of-way easement on Prime Hook and Fowler Beach Roads. Additionally, it owns a 60-foot right-of-way along U.S. 16, also known as Broadkill Road. DelDOT is the responsible agency for the construction and maintenance of these roads.

There are a number of different options to consider for each roadway area that could be affected by restored tidal flows. These include raising the roadway elevation in its current location, tolerating a certain degree or frequency of flooding, and/or abandoning a specific road or portion of road, subject to DelDOT approval and procedures. Hydraulic analysis would be necessary before raising any road crossing the marsh. Some of these roadways are well-traveled and provide access for residents. Prime Hook and Fowler Beach Roads are not adjacent to higher ground, but may need widening. In order to raise these roadways and avoid costly retaining wall construction, the toe of each roadway embankment would need to extend horizontally into adjacent wetland resource areas.

Some low-lying roadways along the coast have historically been subjected to varying degrees of flooding during coastal storms. When such flooding is infrequent, such as during storm events, the effect on the public may be minimal and can be accommodated. Issues to consider include public health and safety relative to access. This would require further assessment as more detailed hydrologic analyses are conducted. At Fowler Beach Road, abandonment may be an option. Any decision on such roadway abandonment would be subject to public hearings in nearby towns.

Planning for reconstruction of these roads must also include an assessment of impacts to fire department and emergency medical vehicle access routes and alternative access options. The refuge has long-standing mutual aid agreements with Milton Fire Department, Inc. and the Memorial Volunteer Fire Department of Slaughter Beach. These agreements need to be updated to better describe the authority and responsibility and to include other emergency situations on refuge lands or adjacent to the refuge.

To maintain a freshwater system, these roads need to be elevated 2 to 4 feet with the sides sloped at a ratio of 3:1. Costs will easily exceed \$1 million per road. Some estimates put the costs closer to \$2 million per road (Service's cost-estimating guide). It should be noted that if Fowler Beach Road is abandoned, costs may be considerably less. Instead of a road, a levee or other type of barricade could serve the same purpose at a fraction of the cost. In either

scenario, costs for road elevation and/or levee construction would range from over \$1 million to \$4 million.

Management Implications:

Significant environmental, physical, structural, monetary, and regulatory hurdles need to be addressed to maintain freshwater impoundments on Prime Hook NWR. The SLAMM model and the State's inundation maps (DNREC, unpublished) predict accelerated rates in sea level rise in the next 50 to 100 years. Portions of the refuge's marshes or impoundments may have already reached a tipping point. It is important to note that the time frame of impoundment management has been relatively short on the refuge, in relation to the time frame of natural coastline processes. Relatively speaking, freshwater impoundment management is not a long-standing management regime on the refuge but was conceived to meet valid wildlife management objectives. It was established, in part, using existing roads, which had not been formally engineered for long-term water level management as dike infrastructure.

Preliminary data indicate portions of our managed impoundments may be losing ground to sea level rise. Unit II, for example, is accreting new sediment at a pace that is half the documented rate of local sea level rise. It is not reasonable to expect that such a large deficit in elevation-capital can be recovered within Unit II under current freshwater impoundment management strategies. Freshwater marshes dominated by annual vegetation differ from salt marshes in that predominantly annual wetland plants contribute to high above-ground biomass, whereas the persistent below-ground organic matter of perennial vegetation, such as that found in tidal salt marshes, makes greater contributions to vertical accretion (Cahoon et al. 2009). This means that the vegetation in salt marshes build up the elevation of the marsh and that freshwater marsh plants do not, so that salt marsh can be sustained in light of rising sea levels but freshwater plants not only die if flooded by saltwaters, they also leave the marsh substrate at a depressed elevation compared to salt marsh species.

Biological Resources of Delaware Bay Estuary

The Delaware Bay Estuary is an important ecosystem recognized nationally, internationally, and globally as a resting and feeding area for millions of migrating birds each spring and fall. It supports rare and endangered species, supports commercial fisheries, and acts as a major horseshoe crab spawning ground on the East Coast. It is an ecosystem where many biogeographic provinces come together, resulting in overlapping habitat types and high biodiversity. The increase in economic pressures on these habitats of the Delaware Estuary dictates that remaining natural uplands and wetlands conserved for wildlife will require extra protection and conservation efforts in the future (Webster 1996).

There are three major ecological zones of the Delaware Estuary, which are distinguished by differences in salinity, turbidity, and biological productivity. The upper zone is tidal freshwater and extends from Trenton to Marcus Hook. The transition zone, which extends from Marcus Hook to Artificial Island, has a wide salinity range (0 to 15 ppt) and is characterized by high turbidity and low biological productivity. The lower zone, where Prime Hook NWR is located, is open bay and extends to the ocean. It has higher salinity distributions fluctuating from polyhaline to euhaline waters (18 to 30 ppt), broad areas of fairly shallow water (less than 9 meters), and over 90 percent of the primary biological productivity of the three zones (Partnership for the Delaware Estuary 1996).

Land use is a term that refers to the way land is developed or conserved. Demographic predictions provide compelling evidence for planning growth and protecting natural resources. Nine of the ten most densely populated U.S. counties are in the Northeast. Because of our love of the water, almost half of the U.S. population now lives in coastal areas, including along the shores of estuaries.

This population trend is accelerating and coastal counties are growing three times faster than anywhere else in the Nation.

Escalating population growth and the demand for new housing, shopping centers and places of employment are projected to rapidly continue throughout the Delaware River basin region between now and 2020 with an overall increase of 14 percent. The States of Delaware and New Jersey are expected to see population increases of 24.3 percent and 21.5 percent respectively, by that date. By 2020, projected development increases of 14 percent will affect over 50 percent of the total land area within the region, leaving less than 50 percent of the land cover in agricultural, wooded, open space, or water (Seymour 1994). Major problems and future threats for living resources of the Delaware Estuary are identified in the 1996 comprehensive conservation management plan.

The Delaware Estuary is one of the most heavily used estuary systems in the Nation. The estuary supports one of the world's greatest concentrations of heavy industry, and the second largest oil refining and petrochemical centers in the U.S. About 70 percent of transported oil (over one billion barrels of crude and refined oil products) reaches the east coast of the U.S. through the Delaware Estuary by way of the ports of Philadelphia, Camden, Gloucester City, Salem, and Wilmington. The estuary also receives wastewater discharges from 162 industries and municipalities and approximately 300 combined sewer overflows. The Delaware River basin supplies 10 percent of the U.S. population (20 million people) with water for drinking and industrial uses. Much of this water is transferred out of the basin through runoff into the Delaware Estuary (Partnership for the Delaware Estuary 1996).

Additional information about the biological resources of the Delaware Bay Estuary, including phytoplankton, benthic organisms, and horseshoe crabs, can be found in the Prime Hook NWR Final CCP/EIS, Volume 1, chapter 3 (<http://www.fws.gov/northeast/planning/Prime%20Hook/finalccp.html>).

Dragonflies. More than 100 species of Odonata occur in the Delaware Estuary. Damselflies and dragonflies (Odonata) have received increased attention as indicators of the health of wetland habitats. Activities that adversely affect water quality or alter specific habitats can eliminate odonate species or alter the composition of an area. The alteration of aquatic environments through channelization, siltation, draining, or chemical spraying has resulted in notable recent declines in many odonates throughout their ranges (Carle 1991). Because odonates are widespread and inhabit all wetlands, their absence could be an early indication of environmental degradation from a variety of sources. Odonates are beneficial to man by consuming large numbers of mosquitoes (Barber 1995).

Fish. More than 200 fish species, both residents and migrants, use the Delaware Estuary. The residents include fresh and saltwater species like the white perch which has a broad range of salinity tolerances. Resident species conduct all aspects of their life history within the estuary. Migrant species are highly dependent on the estuary for spawning habitats and nursery and feeding grounds. Ocean migrants include both warm and cool water species. A large number of migrants, such as the herrings and shad, are anadromous, living in ocean water but migrating to freshwater to breed. One species, the American eel, is catadromous, living in fresh or brackish waters and migrating downstream toward the ocean to reproduce. In the Delaware Estuary, the American eel is a very important resource from both a biodiversity and human use perspective. In all its life stages, eel serves as a prey species for many species of fish, aquatic mammals, and fish-eating birds. Eel continue to support valuable commercial, recreational, and subsistence fisheries in the bay.

Major fish species in the Delaware Estuary include various sharks, skates and rays, shortnose and Atlantic sturgeon, American eel, blueback herring, alewife, American shad, Atlantic menhaden, common carp, various catfish, white perch, striped bass, bluefish, weakfish, spot, Atlantic croaker, black drum, and various flounder species. In the Delaware Estuary, changes in abundance of anadromous species have been historically linked to a decline of available spawning habitat due to obstructions in watercourses (dams, pollution blocks) that prevent access to spawning beds, overall water quality, and overfishing. Destruction and alteration of wetland habitats have decreased available nursery areas for juvenile fish development, and recreational fishing pressure has consistently increased. There are at least 31 species that are commercially harvested from the estuary valued at about \$1.4 million in 1996 (Delaware Estuary-CCMP).

Birds. Four major estuaries in North America are critical shorebird stopover areas, and each supports more than one million shorebirds during migration. These are the Bay of Fundy and the Delaware Bay on the East Coast, and Alaska's Copper River Delta and Washington's Grays Harbor on the West Coast. At these stopover areas, shorebirds feed on amphipods, chironomids, and horseshoe crab eggs and nearly double their weight before moving on. These areas are unique in their mix of natural resources and consistently support high percentages of the entire world's populations of certain bird species.

Historical survey data has recorded that up to 200,000 red knots (80 percent of the Western Hemisphere population), 10,000 short-billed dowitchers, and half the ruddy turnstones in North America visit the Delaware Bay to feed on horseshoe crab eggs. Red knots fly 19,000 miles round-trip between wintering and breeding grounds and rely on one or two staging areas. After leaving its wintering grounds in southern Argentina, the red knot makes only one stop on the coast of Brazil (Lagoa do Peixe), and then flies nonstop to Delaware Bay, which is a distance of 5,000 miles (Chipley 2003).

Total birds counted in aerial surveys in Delaware Bay over the 6-week migration period from May to mid-June range from 250,000 to more than 1,000,000 birds. Birds observed in tidal marsh habitats are estimated at 700,000. Red knots, sanderlings, ruddy turnstones, and semipalmated sandpipers make up 97 percent of the individuals of 30 species of shorebirds utilizing Delaware Estuary habitats. Many migratory raptors, waders, and waterfowl also use the estuary, including brant and up to 400,000 snow geese (State-DE/NJ aerial survey data).

Delaware Estuary Program Priority Species List. In spring 1993 a habitat task force brought experts from across the region to develop a list of priority species for management purposes. Of the thousands of plant and animal species in the estuary, participants extracted the indicator and keystone species and assemblages of species that are critical to maintain and monitor the BIDEH and functioning of the Delaware Estuary. Scientists have deemed that this ecosystem would lack wholeness and integrity without them.

A final list of approximately 100 species and assemblages were identified that are critical in maintaining the Delaware Bay's BIDEH. A supplemental publication to the Delaware Estuary comprehensive conservation management plan describes the habitat requirements and species profile histories of these keystone and indicator species of ecosystem health. The document is entitled "*Living Resources of the Delaware Estuary*" (Dove and Nyman 1995). This information was stepped down to the refuge level when we developed and fine tuned our refuge-specific focal species list and identified the refuge's top priority resources of concern. This process is described in more detail in chapter 2 of this CCP, which describes the planning process.

The Delaware Estuary is impacted by toxic substances, mainly human-created chemicals that have been introduced into the waters. Elevated levels of many

Refuge Biological Resources

toxic substances have been detected in the sediments, the water column, and in the tissues of organisms dependent on the estuary. Primary toxic substances include heavy metals, mercury, and organic contaminants such as polychlorinated biphenyls and Dieldrin. High concentrations of these contaminants of concern have prompted DNREC to post fish consumption advisories from the C & D Canal down to the mouth of the Delaware Bay for following finfish species: striped bass, channel and white catfish, American eel, white perch, and bluefish (DNREC 2010).

As in our discussion of rarity patterns of plant species, we also refer to DNHP rankings in describing refuge biological resources such as birds, invertebrates, reptiles, and amphibian species.

The only resident federally endangered species on the refuge is Federal and State-listed Endangered or Threatened Species the Delmarva fox squirrel (*Sciurus niger cinereus*). The current population is very small but represents the core population for expanding Delmarva fox squirrel habitats on the refuge in coming years. In recent years, due to State-managed areas protecting and increasing piping plover productivity each summer, coupled with expanding overwash habitats and new beach acquisitions on Prime Hook NWR, greater numbers of piping plovers are using refuge sandy beach areas as foraging habitats during spring and fall migration periods. Piping plover breeding has not been observed occurring on the refuge to date.

State endangered resident species on the refuge include two pair of bald eagles. State endangered species that breed on the refuge include pied-billed grebe, northern harrier, Cooper's hawk, black rail, and Forster's tern. In most recent years State endangered species that have attempted breeding on the refuge include American oystercatcher, least tern, and common tern. Uncommon occurrences of other State endangered species using the refuge in the spring, fall, or winter include brown creeper, black-crowned night heron, yellow-crowned night heron, least tern, hooded warbler, red-headed woodpecker, and sedge wren.

Birds

The bird assemblage in the project area is as diverse as its natural vegetation communities. The project area's geographic location on the southwestern shore of the lower mouth of the Delaware Bay situates the refuge at the heart of key staging areas for migrating, breeding, and wintering habitats for waterfowl, shorebirds, waterbirds, and land birds along the Atlantic Flyway and in the Western Hemisphere. The refuge is located in the Northeast BCR 30 and PIF Physiographic Region 44 of the Mid-Atlantic.

The project area has also been designated a significant site for shorebirds within the Western Hemispheric Shorebird Reserve Network (WHSRN 1986), a Ramsar Wetland Site of International Importance (1992) and an Important Bird Area of the Delaware Bay in 2000.

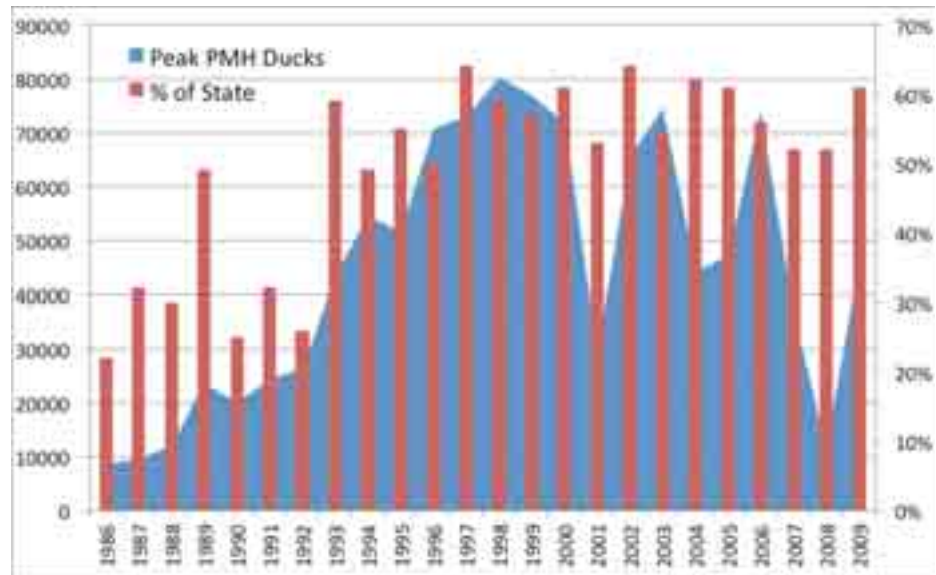
Waterfowl

Waterfowl have been a target species group for refuge management since the refuge was first established. In the past, the refuge farming program was focused on providing food for certain duck species (mallard, American black duck, northern pintail, and wood duck) and Canada geese during the fall, winter, and spring. A secondary objective of the farming program was duck production, for which croplands in grass or clover stages of rotations were designed to provide nesting habitats for ducks. In addition, waterfowl have utilized the refuge's wetland habitats, throughout several different phases of wetland management.

Waterfowl management on the refuge greatly improved habitat conditions for migrating and wintering birds when water level management capability was established in the mid-1980s. Excellent freshwater wetland habitat conditions providing abundant food resources are reflected by subsequent increased bird use of the refuge after 1986. For example, in October 2005, the refuge hosted 52

percent of waterfowl surveyed in Delaware, 71 percent of the State's snow geese, 82 percent of Northern pintails (22,800 birds), 54 percent of American green-wing teal (20,360), and 40 percent (1,889) of the State's American black ducks wintering in Delaware (DNREC, personal communication). Peak duck numbers of 47,116 ducks wintering on the refuge's marsh-complex represented 61 percent of the State's peak number of ducks (figure 3-16).

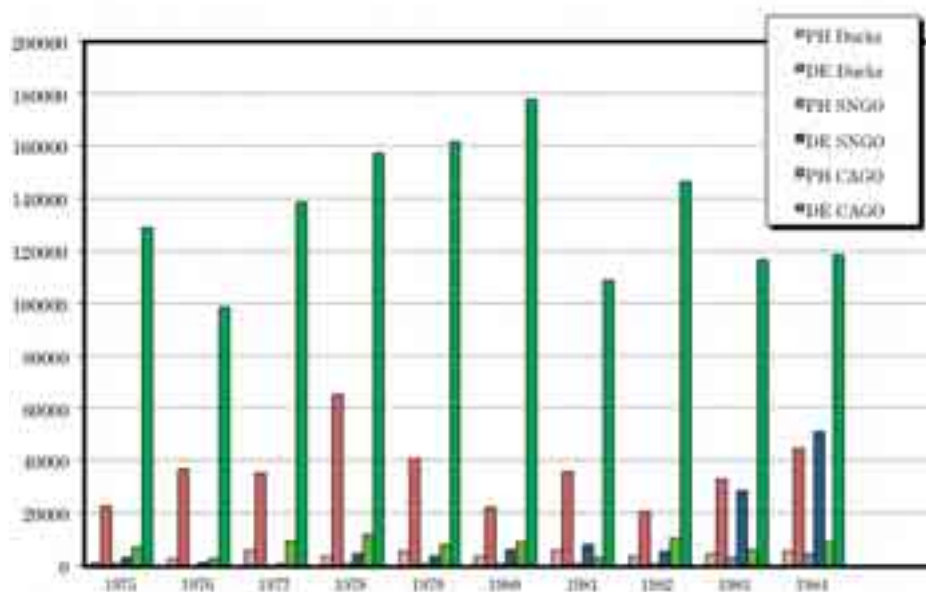
Figure 3-16. Peak Duck Populations Counted on Prime Hook NWR Marshes as a Percent of Delaware's Statewide Peak Duck Numbers



Historically, the Delaware Division of Fish and Wildlife has conducted aerial waterfowl surveys each year to measure long-term trends in duck and goose populations in the State. These surveys were flown in a small plane by the same waterfowl biologist for 30 years, using the same routes and techniques each time. The survey biologist staff changed after 2005, but DNREC waterfowl biologists have continued to provide waterfowl survey data directly to the refuge. These surveys cover the primary waterfowl habitats found in Delaware. The surveys give fairly accurate information about geese and most duck species with the exception of wood ducks and sea ducks, which are almost impossible to count from a fixed-wing aircraft. The important feature of these counts is that they provide long-term trends that are useful to measure changes in waterfowl management strategies and the environment. In most cases, no single count is especially important in itself but the collection of counts over the years has shown significant changes. These surveys detected the decline in the migrant Canada geese in the Atlantic Flyway, the loss of duck use in Christiana marshes after the construction of I-95, and recent increases in ducks using Prime Hook NWR. An analysis of this 30-year data set shows how marsh restoration and rehabilitation projects, after an early period of no management, improved habitat conditions for waterfowl.

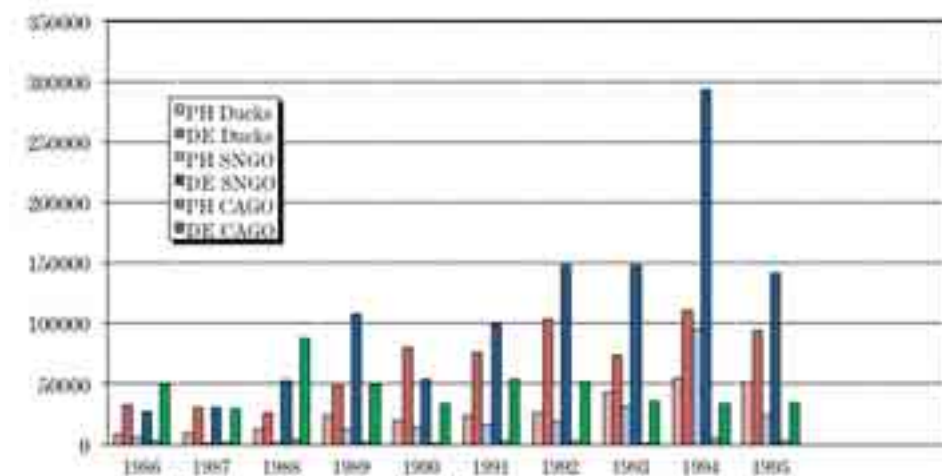
During a decade of the no wetland management era, proliferation and invasion of *Phragmites* throughout the refuge's wetland areas reduced the quality of habitat conditions for ducks. During this time, average duck use of refuge marshes was 3,905 birds (peak 5,795 to low of 2,254), which accounted for less than 10 percent of the State's total duck numbers. Average snow goose numbers were 748 birds, ranging from 0 to 4,310 birds. State average totals for snow geese were 11,000 and ranged from 678 to 50,726 birds. State migratory Canada goose numbers were at an all time high of 177,811 birds in 1980 and refuge peak numbers of Canada geese during this decade were 11,942 birds in 1978 (DNREC personal communication). For waterfowl population distributions and use of refuge marshes compared to Statewide numbers (figure 3-17).

Figure 3-17. Average Waterfowl Use during the No Wetland Management Era



During the next decade of marsh rehabilitation of Prime Hook NWR's wetlands consisted of the large-scale control of *Phragmites* and establishment of impoundment infrastructure, waterfowl use increased. These habitat improvements and increased waterfowl use on the refuge are reflected in the State of Delaware's waterfowl aerial survey data. Statewide, ducks numbers doubled from the 1986 to 1995 period compared to the 1975 to 1984 period, while duck use and numbers on the refuge increased sevenfold, ranging from a low of 8,582 ducks in 1986 to a peak of 54,606 in 1994. Pintails (28,920) and green-winged teal (39,611) were the duck species contributing the highest total numbers to duck counts during this period. Snow geese also showed increases on the refuge and throughout the State. Peak snow goose numbers recorded in 1995 for the refuge were 95,300 birds and 293,651 birds for the State. In contrast, Canada geese numbers dropped sharply with average numbers during the 10-years of no management of 7,486 dropping to 2,573 birds during the marsh rehabilitation era. Likewise, Statewide numbers of Canada geese dropped from an average of 135,213 birds down to 45,678 birds in the second decade of trend monitoring data (figure 3-18) (DNREC, personal communication).

Figure 3-18. Average Waterfowl Use during Marsh Rehabilitation Era



Continuing this 30-year trend analysis, during the intensive wetland management strategies of integrative moist-soil management, waterfowl use of Prime Hook NWR's marshes continued to increase. Teasing out the duck numbers from the waterfowl data, the State experienced a general 37 percent increase in duck numbers during this decade (1996 to 2005), while Prime Hook NWR recorded a 72 percent increase from prior decades in duck use. At Prime Hook NWR, duck use ranged from a low of 29,638 ducks in 2001 to a high of 80,261 ducks in 1998.

Increases in snow goose numbers were recorded both Statewide and refugewide. Peak snow geese numbers on the refuge were 143,432 birds occurring in 1999 and a low of 13,775 snow geese in 2005, compared to a Statewide high of 371,715 birds in 1997 and low of 91,654 also in 2005. Canada goose numbers using the refuge doubled from the prior decade but Statewide Canada goose numbers continued to spiral downward.

Thirty-two waterfowl species have been recorded using refuge habitats. The two duck species contributing the most in the 30-year trend data analysis were green-winged teal and northern pintail. Green-winged teal numbers were 41,047 in 1996; 46,795 in 1997; 53,260 in 1998; and 65,727 in 1999; and peak northern pintail numbers include 28,920 in 1993; 21,061 in 1998; 21,835 in 2000; and 35,497 in 2003. Other duck species contributing to duck totals included American black duck, mallard, gadwall, American wigeon, northern shoveler, wood duck, scaup, ring-necked duck, ruddy duck, and hooded merganser.

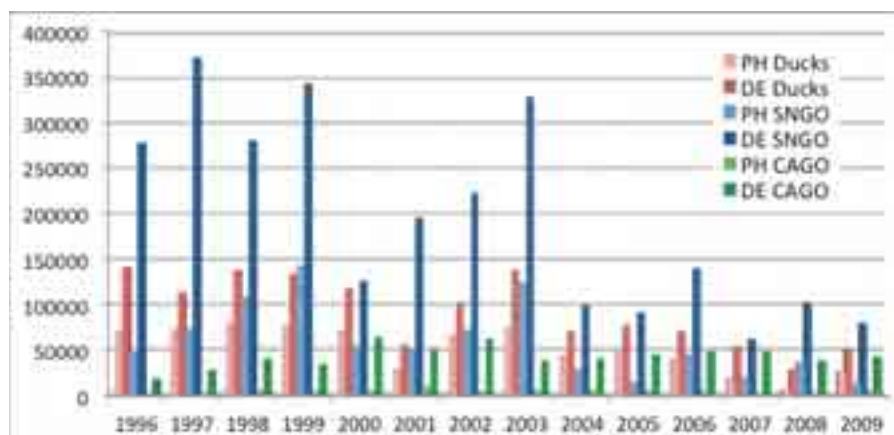
By means of marsh rehabilitation and integrative moist-soil management techniques through water level manipulation strategies, Prime Hook NWR has demonstrated considerable success in increasing both waterfowl and shorebird use of the refuge's wetland habitats simultaneously. Fredrickson and Laubhan (1994) described how intensive wetland management strategies are the keys to enhancing biodiversity in the face of continuing wetland degradation and loss throughout all landscape scales.

The basic premise of intensive wetland management is producing a diverse array of plant and animal food resources that can feed a greater abundance of target species of waterfowl and shorebirds on smaller patches of marshland. Intensive wetland management has demonstrated improvement in wetland productivity and biodiversity when the correct combination of water level manipulations and other habitat management techniques are applied at the appropriate times for an array of target wetland species (Fredrickson and Laubhan 1994).

The general strategy of intensive wetland management is predicated on knowing the life history requirements of target waterfowl and shorebird species, annually creating abundant native plant and animal food resources consistently, and making these annually produced food resources available to target species at the right time of the year.

Annually from 1995 to 2005, Prime Hook NWR attempted to match the chronology of particular biological events such as molting, migration, and reproduction requirements of target waterfowl and shorebird species with specific water level drawdown and reflood regimes conducted asynchronously between the refuge's three impoundment units. Concurrent waterfowl and shorebird habitat management can be accomplished each year by producing abundant invertebrate food resources and then linking drawdowns to local migration phenology. Management success is reflected in the bird use data (figure 3-19).

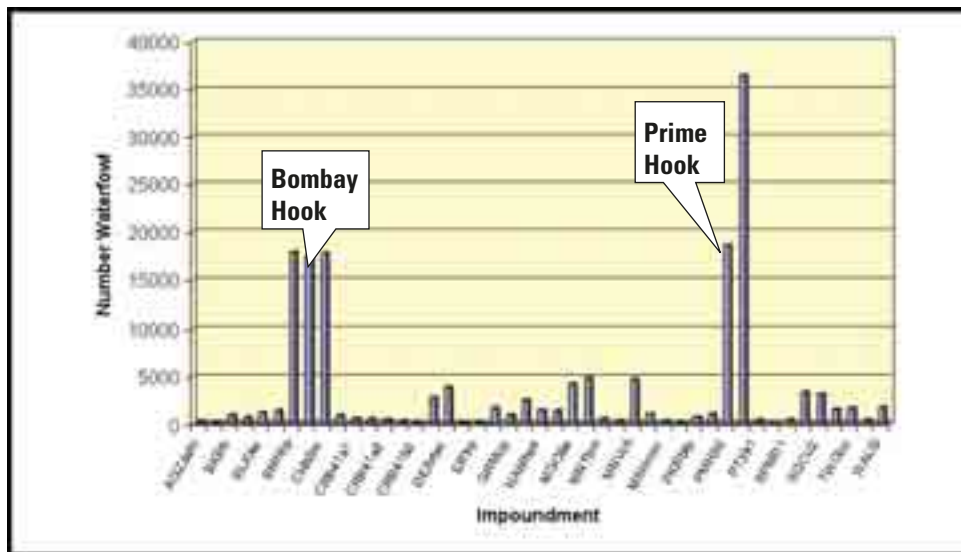
Figure 3-19. Average Waterfowl Use during the Integrative Wetland Management Era



Managed wetlands provide a broad spectrum of resources to migratory birds throughout the annual cycle. Successful conservation and management of waterfowl, shorebirds, and waterbirds depend on integrated approaches. Few managed wetlands have the capability to provide habitat during both spring and fall migration. Whether management actions are designed to benefit spring or fall migrant shorebirds, hydrologic regimes will also impact waterfowl and other waterbirds, primarily through changes to invertebrate and plant communities. With this in mind, the refuge participated in a 3-year, multi-regional wetland management study from 2005 to 2007 to understand the differential impacts of spring versus summer/fall drawdowns on the vegetation structure, invertebrate communities, and use of impoundments by waterfowl, shorebirds, and other waterbirds (USGS 2005). The refuge used study areas in Unit III (PMH3D) and Unit IV (PMH4A).

Preliminary analysis of study results (Green et al 2007) after two seasons of field data (2005 and 2006) indicated that early spring drawdowns conducted in PMH3D to prepare habitat conditions for spring migrating shorebirds, also yielded excellent waterfowl use in mid-November in the same wetland, with more than 20,000 ducks and geese recorded using the area. During the same timeframe PMH4A experienced a late summer drawdown targeting fall migrant shorebirds which also generated excellent waterfowl use with a peak of 15,000 birds using the same wetland by the first week of November. Of the 22 national wildlife refuges from regions 3 and 5 participating in this study, most refuges recorded waterfowl use in the tens and hundreds range while Prime Hook and Bombay Hook NWRs recorded waterfowl numbers in the thousands of birds range, indicating the importance of the Coastal Delaware NWR Complex to waterfowl resources (figure 3-20). A final analysis and study report will soon be released by USGS.

Figure 3-20. Relative Abundance of Waterfowl Using Refuge Impoundments Enrolled in Multi-Regional Impoundment Study. Note importance of Delaware refuge impoundments.



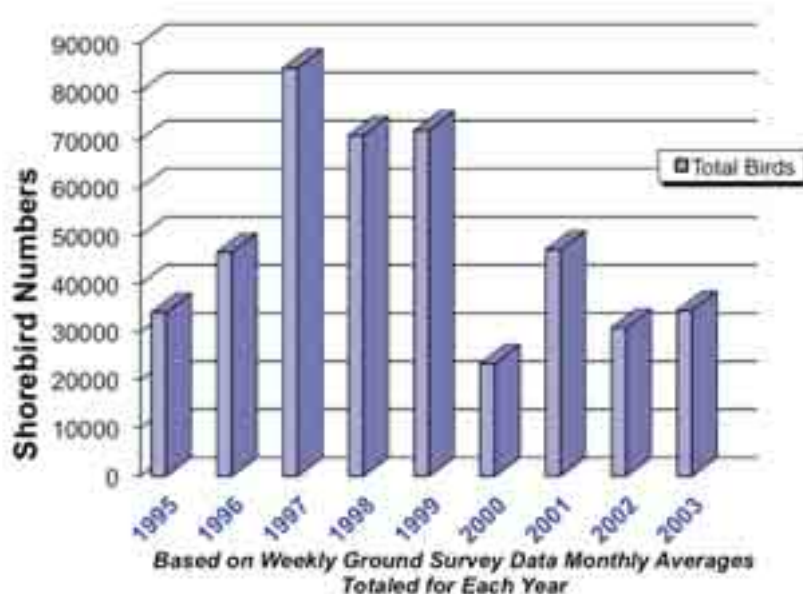
Shorebirds, Gulls, Terns, and Allied Species

The refuge provides diverse fresh and saltwater marsh and impoundment habitats that support 54 species of shorebirds, gulls, terns, and allied species. Most species are migrants, but 13 of these species breed on the refuge (black rail, clapper rail, king rail, Virginia rail, sora, common moorhen, American coot, killdeer, black-necked stilt, willet, spotted sandpiper, American woodcock, and Forster's tern), while 12 species winter in marsh habitats (sanderling, killdeer, American woodcock, willet, greater and lesser yellowlegs, western sandpiper, dunlin, common snipe, ring-billed, herring, and lesser black-backed gulls). Common terns, least terns, and black skimmers seasonally utilize refuge habitats; these three bird species are on the State's endangered species list.

Refuge saltwater marsh, sandy beach, and impoundment habitats support a shorebird migration that has worldwide ecological significance. Abundance of invertebrate foods is recognized as an important determinant of habitat quality for migrant shorebirds. High densities of chironomid larvae are common in the diets of breeding, migrating, and wintering shorebirds (Batzner et al. 1993). As previously mentioned, intensive management of Prime Hook NWR's seasonally flooded impoundments for migrant shorebirds has been a part of the refuge's habitat management strategies by incorporating methods to increase annual invertebrate biomass production. It is possible to successfully manage for such macroinvertebrates as chironomids and other short-cycle invertebrates, purposefully for shorebird consumption, using water level manipulations to produce invertebrate densities of at least 100 individuals per square meter (Baldassarre and Fisher 1984, Helmers 1992). The essence of successful shorebird management within impounded wetland habitats is based on the seasonal production of high densities of macroinvertebrates and their availability at critical times of the year for spring and fall shorebird migrants (Rundle and Fredrickson 1981, Elridge 1992).

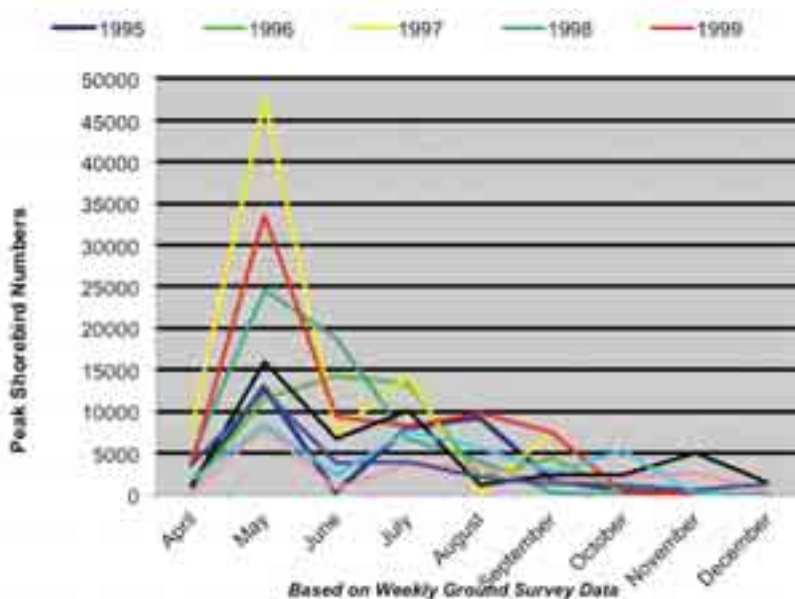
Manipulating water levels at the appropriate times to create areas with a mosaic of open mudflats with shallow water levels (between 1.0 and 10.0 cm deep) and invertebrate densities of at least 100 individuals/M² have yielded excellent results on the refuge. A decade of shorebird ground surveys were conducted weekly from April to December on Prime Hook NWR's impounded marsh units (figure 3-21).

Figure 3-21. Refugewide Shorebird Use of Prime Hook NWR's Impoundments



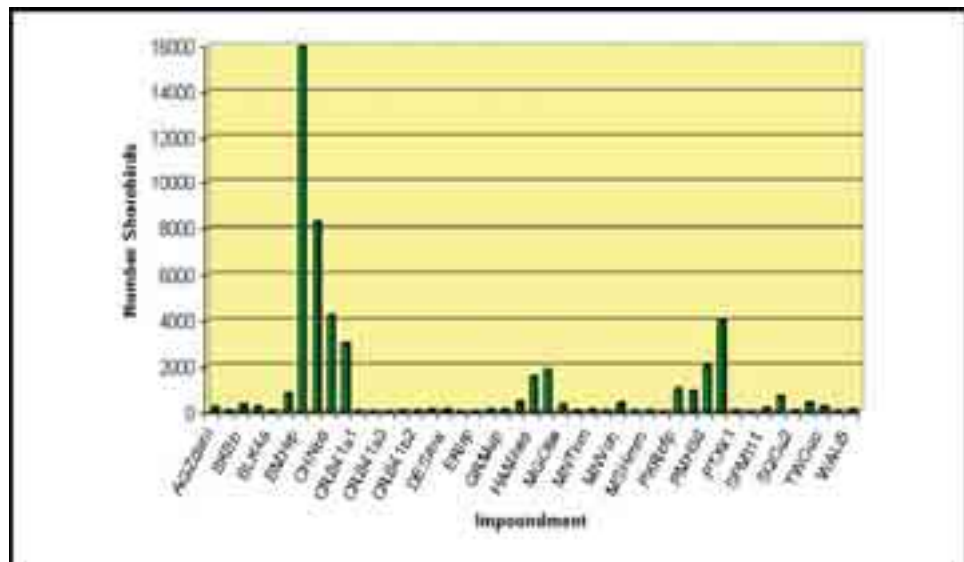
Dominant shorebird species contributing to shorebird numbers on Prime Hook NWR from weekly ground surveys included the following spring migrants: semipalmated sandpipers, short-billed dowitchers, dunlin, sanderlings, and red knots; and fall migrants: short-billed dowitchers, semipalmated plovers and sandpipers, dunlin, least sandpipers, and yellow-legs. Chronology of use information for the years of 1997, 1998, 2000, 2001, 2002, and 2003 shows that spring migrants start arriving by mid-April and peak during the last 2 weeks of May, while fall migrants start arriving by the last week of June and peak during the first 2 weeks of July. Local spring migrants arrived 2½ weeks later in 1996 and peak fall migrant numbers were 3 weeks later in 1995 and 1999 (figure 3-22).

Figure 3-22. Chronology of Shorebird Use at Prime Hook NWR



As previously mentioned in the waterfowl section, the refuge participated in a multi-region refuge cooperative research impoundment study, whose primary objective was to monitor management actions that created shallow water and mudflat habitat for shorebirds either for the northward or southward migration. While management actions targeted shorebird habitat creation within the impoundments, we also simultaneously monitored the responses of waterfowl and wading birds in addition to shorebirds. The preliminary shorebird monitoring results (Green et al. 2007) suggest that both early spring drawdowns and late summer drawdowns generated greater numbers of fall migrants (peak about 4,000 birds) using Units III and IV impounded study sites, compared to spring migrants (peak about 1,500 birds). Chronology of use plots suggest that the first week of September was when the greatest shorebird use occurred (about 3,000 birds) in Unit III during 2005 and 2006; fall migrant shorebird use in Unit IV occurred in mid-August, and again September 1st and mid-September (about 4,000 birds for all 3 plot peaks) during the same timeframe as Unit III. Preliminary results suggest that refuge impoundments are more important for the southward migration. Overall, impoundments at Prime Hook NWR, as well as Bombay Hook NWR also in Delaware, are clearly important to migratory shorebirds, relative to other impoundments evaluated in the study (figure 3-23). A final study report is pending that will analyze and compare study results of 22 national wildlife refuges representing regions 3 and 5.

Figure 3-23. Relative Abundance of Shorebirds Using Refuge Impoundments Enrolled in Multi-Regional Impoundment Study. Note importance of Delaware refuge impoundments.



Marsh and Water Birds

Freshwater impoundments, brackish marsh, and salt marsh wetland areas provide excellent feeding and resting areas for 30 species of marsh and water birds. Pied-billed grebe, least bittern, and green herons all nest on the refuge. Pied-billed grebes are on the State endangered species list and American bitterns and little blue herons use refuge habitats for portions of the year. These three species are ranked as (S1) species of special conservation concern in the Delaware Wildlife Action Management Plan (2005).

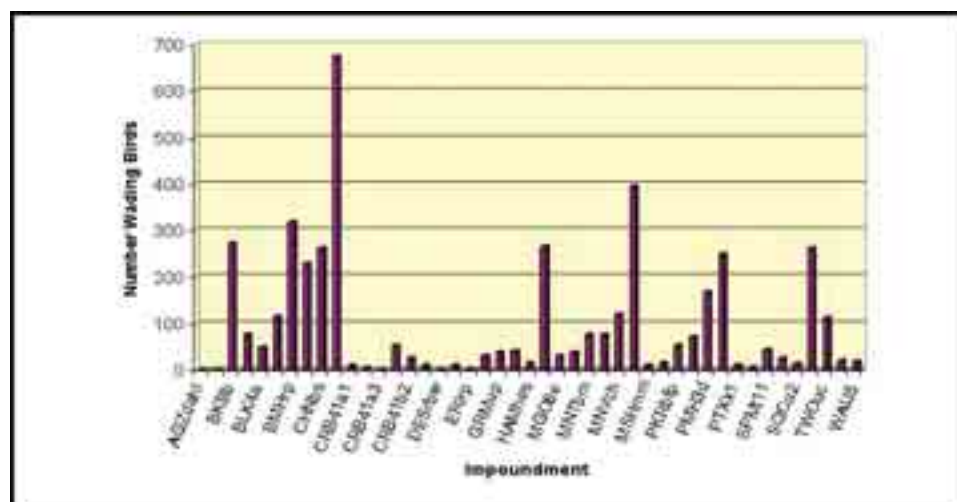
The most important heron and egret rookery in Delaware is located in the middle of Delaware Bay Estuary on a 310-acre island named Pea Patch Island. Located about 54 miles north of the refuge, it is the largest heronry on the East Coast north of Florida. It is a resource of both regional and national significance. Ten species of herons, egrets, and ibises nest on this isolated island, which supports

3,000 nesting pairs of wading birds. Many of these birds spend the months of August and September feeding on diverse and plentiful fish resources found in refuge habitats. Of particular note are the black-crowned and yellow-crowned night herons found on the refuge during this timeframe which are listed as State endangered bird species of Delaware.

The Mid-Atlantic/New England/Maritime Waterbird Conservation Plan (2006) has identified the highest priority species in need of immediate conservation action. Highest priority species that breed or migrate through the refuge include pied-billed grebe, American bittern, least bittern, snowy egret, little blue heron, tricolored heron, black-crowned night heron, glossy ibis, black rail, least tern, gull-billed tern, common tern, black skimmer, yellow rail, sora, black tern, and Forster's tern.

An integrated wetland management approach to create optimal shorebird habitats at appropriate times for spring and fall shorebird migrants can also provide a broad spectrum of resources for marsh and water birds. This group of birds was also targeted for monitoring during the Refuge Cooperative Research Program Region 3/5 Impoundment Study previously mentioned in the waterfowl and shorebird sections of this chapter. The objective of conducting management actions to create shallow water and mudflat habitats for shorebirds and monitor the subsequent responses of invertebrate populations and plant communities also included monitoring water bird use of the various seasonal habitat conditions that were generated during the study in PMH3D and PMH4A. Preliminary data analysis (Green et al. 2007) indicated that marsh and water birds utilized impounded wetland study sites throughout the year, with peak use occurring during mid-August and September during the 2005 and 2006 field seasons. Peak water bird use in PMH4A occurred in late August (approximately 350 birds) and peak use in PMH3D (approximately 250 birds) occurred during the first week in September (figure 3-24).

Figure 3-24. Relative Abundance of Wading Birds Using Refuge Impoundments Enrolled in Multi-Regional Impoundment Study.



nuthatches, and short and long-distance neotropical migrants such as flycatchers, swallows, wrens, thrushes, vireos, and warblers.

Many landbird species require large forest areas to breed successfully and maintain viable populations. This diverse group includes songbirds (tanagers, warblers, and vireos), which breed in North America and winter in Central and South America, and residents and short-distance migrants, such as woodpeckers, owls, hawks, and eagles. According to breeding bird survey data since 1966, there has been a 60 percent decline in occurrence of individual birds of landbird migrant species in Maryland and an 83 percent decline in Delaware from 1980 to 2007 (Sauer et al. 2008).

Baseline information about Prime Hook NWR's landbird community during the breeding season is necessary for planning management activities that will contribute to the conservation of targeted resources of concern. A standardized point count survey route for breeding landbirds was established on Prime Hook NWR in 1998 using 40 points all located in fragmented upland forested habitats throughout the refuge.

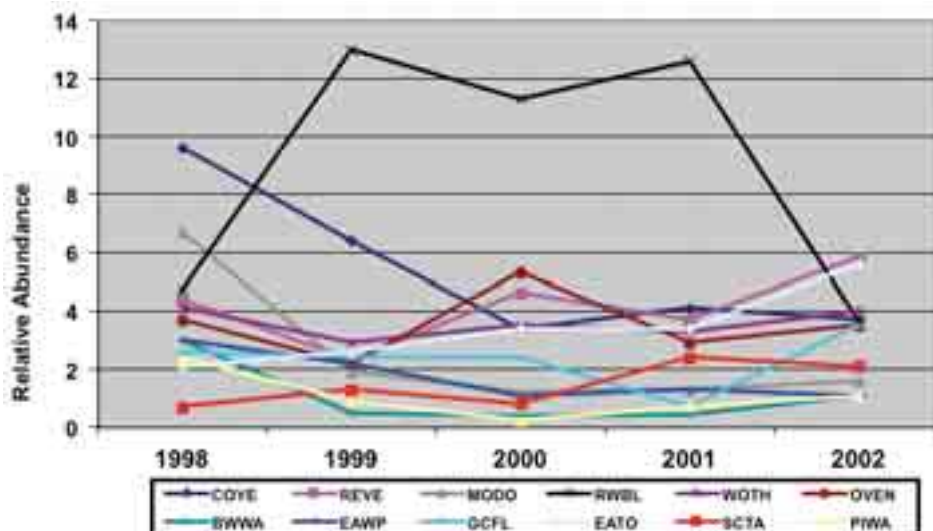
Information gathered from landbird breeding surveys conducted from 1998 to 2005 on Prime Hook NWR showed a wide variety of landbird species utilizing refuge habitats. Monitoring data was archived in the wildlife inventory census database and analyzed. Of the 40 points surveyed on the refuge landbird monitoring route, 70 species were recorded in 1998, 53 in 1999, 64 in 2000, 47 species in 2001, and 49 species in 2002. Monitoring data reflected only 36 points surveyed in 2001 and 32 points in 2002.

Data analyses were conducted separately for each individual species detected during each annual breeding landbird survey. The parameters used for each landbird species during the breeding season were species occurrence (presence/absence), frequency of occurrence, and relative abundance. The frequency of occurrence was calculated using species occurrence values at each point and was represented by the percentage of sampled points of the whole survey route in which the species was detected. The top 12 most abundant species with the greatest distribution across the refuge monitored from 1998 to 2002 are listed below:

Breeding Landbird Species	Frequency of Survey Points
COYE (Common Yellowthroat)	(31 – 71%)
REVE (Red-Eyed Vireo)	(28 – 68%)
MODO (Mourning Dove)	(16 – 27%)
RWBL (Red-wing Black Bird)	(28 – 48%)
WOTH (Wood Thrush)	(31 – 48%)
OVEN (Ovenbird)	(25 – 48%)
BWWA (Black and White Warbler)	(8 – 37%)
EAWP (Eastern Wood Pee-wee)	(9 – 37%)
GCFL (Great-Crested Flycatcher)	(11 – 38%)
PIWA (Pine Warbler)	(2 – 32%)
EATO (Eastern Towhee)	(30 – 53%)
SCTA (Scarlet Tanager)	(10 – 33%)

The relative abundance was calculated as the mean number of individual species detected per point on the refuge during a sample year. This variable provided an index for comparing the abundance of different species and for quantifying the rate of population change of a single landbird species across years on the refuge (figure 3-25).

Figure 3-25. Prime Hook NWR Breeding Landbird Survey Data



Based on relative abundance data, it seems that red-winged blackbirds had good and poor breeding years but the numbers on the refuge do not indicate a significant negative trend. However, compared to National Breeding Bird Survey data sets from 1966 to 2004 for both region 5 and BCR 30, significant declining trends are indicated in both R5 ($P = -2.2734$) and BCR-30 ($P = -0.2767$) when (P less than 0.1) for this wetland breeding species.

Scrub breeders like common yellowthroat and pine warbler are showing significant negative trends on the refuge along with region 5 and BCR 30 data sets. Woodland breeders on Prime Hook NWR, like the eastern wood peewee, black and white warbler, and ovenbirds showed declines in breeding numbers, while red-eyed vireos and wood thrush numbers were stable on the refuge for the past five years. However, these five landbird species have demonstrated significant negative trends in the breeding bird survey data trend sets (Sauer et al. 2005).

Cavity nesters such as great-crested flycatcher and woodland nesters such as scarlet tanager showed no significant trend declines on the refuge, but trend data from regional data sets revealed slight declines for these two species. Although not present in high numbers (five occurrences or less), records of short-distance and long-distance neotropical migrants breeding on the refuge and captured in these landbird surveys included American redstart, northern parula, Acadian flycatcher, blackpoll warbler, black-throated green warbler, summer tanager, chestnut-sided warbler, prairie warbler, hooded warbler, prothonary warbler, yellow warbler, blue-wing warbler, yellow-rumped warbler, eastern phoebe, cerulean warbler, worm-eating warbler, yellow-breasted chat, and yellow-billed cuckoo.

Between May 2001 and October 2003, the Service, in partnership with USGS, conducted a study of grassland-breeding bird abundance and diversity in some of the largest grassland fields existing on 13 refuges in region 5, including Prime Hook NWR (Runge et al. 2004). Each refuge evaluated at least two fallow fields (e.g., abandoned agricultural fields or old pastures maintained by mowing or burning) at least 12 to 16 hectares (ha) in size, in a surrounding non-wooded landscape of 25 ha. Grassland bird density differed substantially among refuges ranging from a low of 0.04 obligate birds/ha at Eastern Neck NWR (Maryland)

to 4.77 obligate birds/ha at Missisquoi NWR (Vermont). The density of obligate grassland birds detected at Prime Hook NWR was 0.19 birds/ha. While many of the refuges showed the potential to sustain densities of obligate grassland birds that were at least comparable to midwestern habitats, Prime Hook NWR showed some of the lowest densities, much less than midwestern habitats or other refuges in the region. For all of the refuges, fields planted with warm-season grass did not support much higher densities of obligate grassland birds than their cool-season or fallow counterparts.

The abundance of grassland birds supported on the fields enrolled in the study shows a similar pattern to the density. These results are affected by the area of the fields, and thus demonstrate a better measure of the relative contributions each refuge could make. The refuges along the Delaware Bay (Supawna Meadows NWR, Bombay Hook NWR, and Prime Hook NWR), and upper Eastern Shore of Maryland (Eastern Neck NWR), have the lowest abundance of grassland birds and the lowest relative contributions of obligate grassland birds in fallow fields among refuges in the Northeast. In terms of species composition, the refuges on the Mid-Atlantic Coastal Plain also show a distinctive community composition, dominated primarily, and almost exclusively, by grasshopper sparrows. The species detected at Prime Hook NWR, albeit in very low numbers, were mostly grasshopper sparrows and horned larks, as well as eastern meadowlarks and sedge wren.

Very few terrestrial species are resident or reproduce in vegetated portions of the harsher environments of salt marshes (Greenberg et al. 2006). However,

obligate salt marsh passerines, such as seaside sparrows, thrive on the refuge salt marsh areas. These salt marsh obligate species can serve as indicators of healthy salt marsh habitats because of their strong relationship with ecosystem structure and function, and because they are easier to sample compared to other environmental health parameters (DeLuca et al. 2004). The refuge monitors their presence and, as staff and resources permit, their breeding productivity.

The refuge also serves as critical stopover habitat for migrating landbirds. Researchers have been reporting for decades on the particular importance of wooded habitats along the Atlantic coast to migrating songbirds for cover and food sources at this vulnerable stage in their life cycles. Preliminary analysis of National Weather Service Doppler

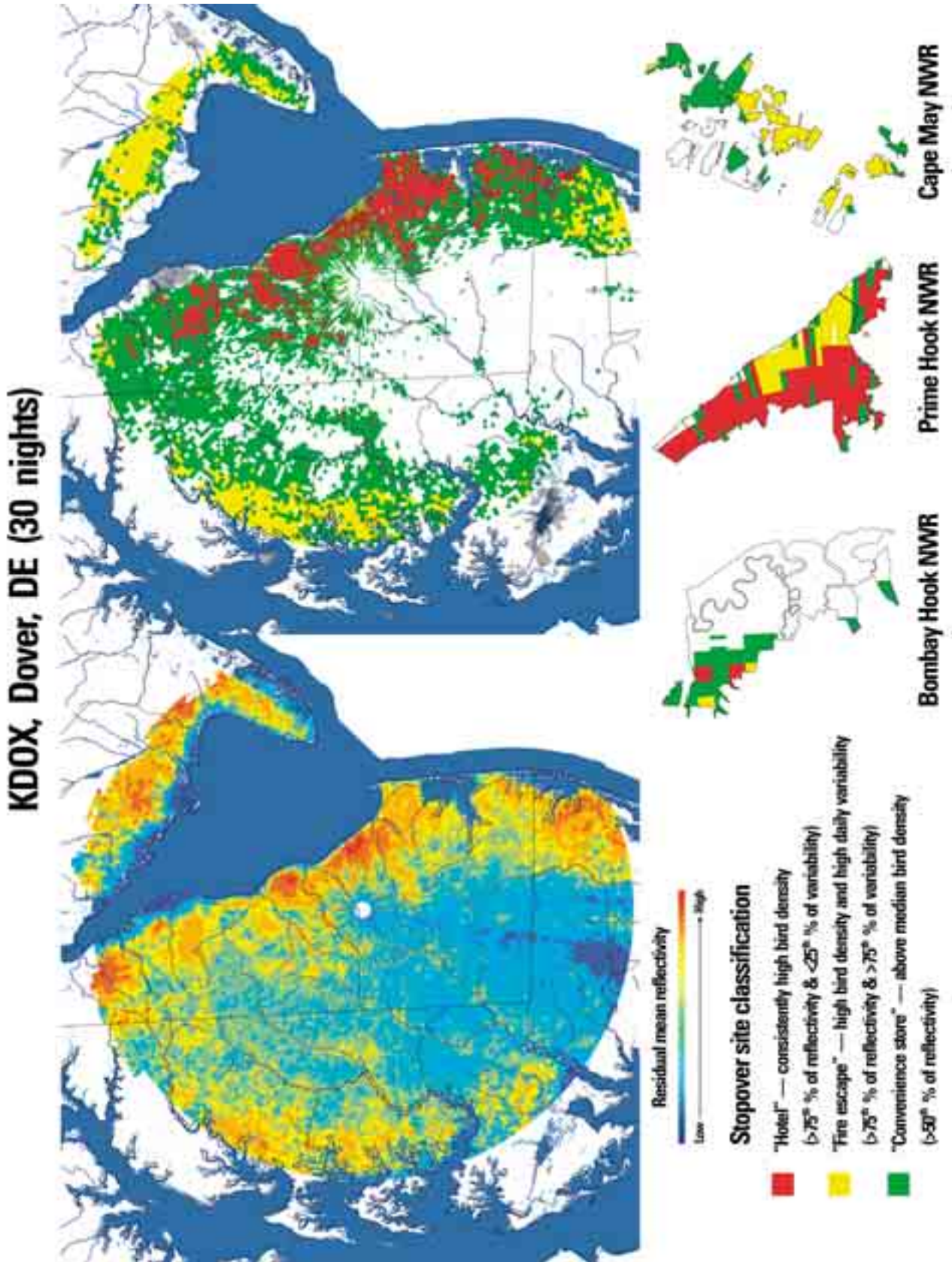
radar data (Dawson and Buler 2010), has underscored the importance of forested wetland cover on Prime Hook NWR to migrating songbirds (figure 3-26). Forested wetlands on the refuge are consistently used by songbirds in very high densities during migration periods, as are a number of large, forested patches outside the refuges. Birds were detected as they left daytime stopover sites at dusk to resume nocturnal migratory flight.



©Chuck Fullmer

Black and white warbler

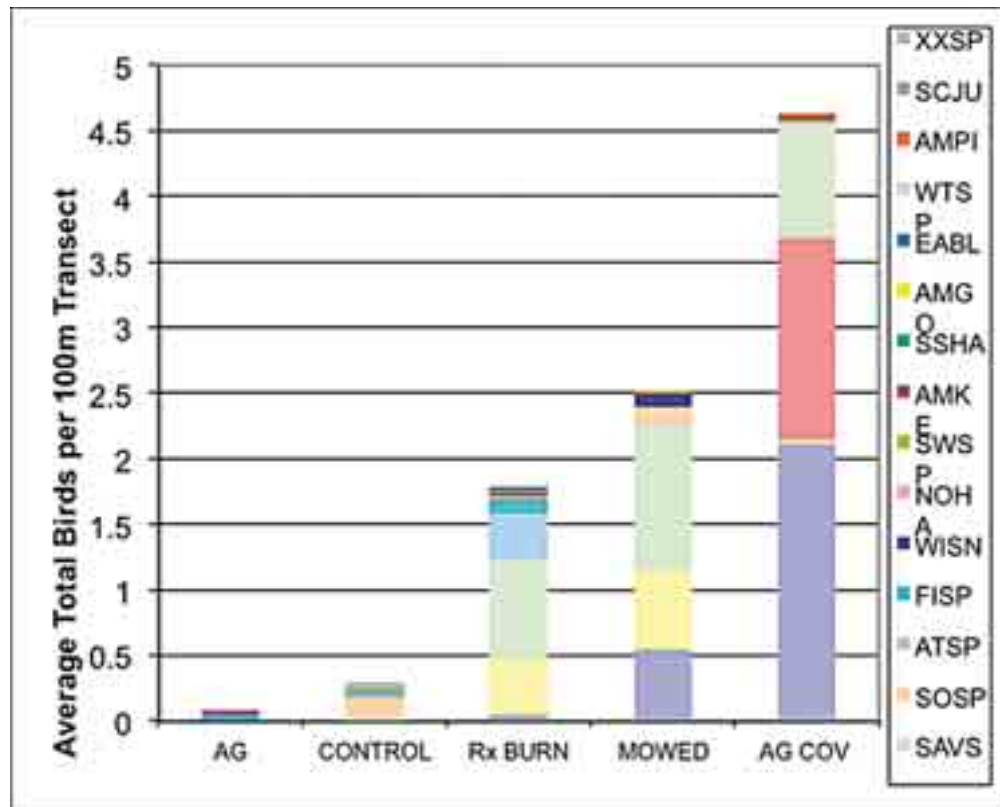
Figure 3-26. Residual mean radar reflectivity (i.e., relative bird stopover density) and stopover site classification during fall 2008 and 2009 in the area sampled by radar station KDOX, located roughly 35 km S of Dover, DE. Figure taken Dawson and Bulter (2010).



The refuge may also be providing valuable overwintering habitat for landbird species of conservation interest, such as grassland specialists. In 2003 to 2004, the refuge participated in a pilot wintering grassland bird survey. The primary objective of the survey was to evaluate survey techniques, timing, and duration. Wintering grassland birds are difficult to survey because they are less abundant, less vocal and active and often patchily distributed and spatially and temporally unpredictable (e.g., found in flocks that move throughout suitable habitat). The pilot surveys provided baseline data regarding the abundance and species composition of grassland birds using some of the managed open fields on the refuge.

The pilot study involved a series of survey transects in each sampled field, across 2 to 4 days, once per month (December 2003, January 2004, and February 2004). Five fields with varying cover types or recent management history were surveyed during the pilot study: Field 202A (mowed), Field 321 (burned), Field 332 (control - unmanaged fallow), Field 318 (agricultural), and Field 202B (agricultural with winter wheat cover crop). Seventeen species were detected in the fields over the course of three separate survey bouts. Because the total length of transects surveyed varied with field size and transect configuration, survey results were calculated as the average number of birds detected per day, per 100 meters of transect sampled. In general, Field 202B had the highest average number of birds, which was driven primarily by a large number of horned larks and red-winged blackbirds using that field, especially during the February survey bout. The greatest species diversity was found in Field 332, the unmanaged fallow field (control), and Field 321, the burned grassland field. Savannah sparrows and eastern meadowlarks preferred Fields 202A and 321, the two managed grassland fields (figure 3-27).

Figure 3-27. Average number of birds detected per 100 meters of transect surveyed in five fields at Prime Hook NWR during winter 2003 to 2004.



Finfish and Shellfish

Refuge fishery resources are extensive and very diverse. The broad goals of refuge fishery management have been to maintain and improve the quality of aquatic habitats for a well-balanced community of fish and other aquatic species, provide fish passage for anadromous fish species, and offer quality recreational fishing opportunities compatible with the refuge's purposes. Current refuge aquatic environments support 52 species of fishes, 4 species of shellfish, and nursery habitats for elvers, striped bass, river herring and other anadromous fish species, and blue crabs.

Early surveys of refuge fishery resources (1969) indicated that 23 species of fishes utilized refuge waters and that largemouth bass, chain pickerel, black crappie, pumpkinseed sunfish, and bluegill were the predominant game fishes of freshwater habitats. Rough fishes such as common carp, creek chubsucker, and gizzard shad were also abundant. Updated surveys conducted in the late 1990s and salt marsh research studies conducted from 2000 to 2004 have supplemented refuge fishery inventory data. See appendix D for a list of the fishery resources found on the refuge.

In its State Wildlife Action Plan (2005), Delaware has identified species of greatest conservation need and placed them in a two-tier system based on endangered and threatened status, significant/sensitive Delaware populations, State and global rankings, highest BCR 30 rankings, and American Fish Society vulnerability rankings. Tier 1 species found on the refuge include blue crab, mud sunfish, and yellow bullhead. Tier 2 species include comely shiner, banded sunfish, fourspine stickleback, and hickory shad.

Additional information about finfish and shellfish resources of the refuge can be found in the Prime Hook NWR Final CCP/EIS, Volume 1, chapter 3 (<http://www.fws.gov/northeast/planning/Prime%20Hook/finalccp.html>).

Mammals

During the settlement of North America and heavy exploitation of the land, nearly all the native mammal species of what is now the eastern U.S. suffered radical declines in numbers. Several species are threatened and endangered. Of notable exception is the white-tailed deer, which has done well in recent years due to extirpation of larger predators coupled with unnatural subsidies of rich food resources in the form of agricultural crops. The white-tailed deer is the most important big game animal in Delaware and the eastern U.S. In Delaware over 15,000 deer are reported in annual harvests and the refuge kills about 130 deer per year.

Prime Hook provides habitats for 37 species of mammals. Thirty-four are native to Delaware and four are exotic. Four of the native mammalian species are ranked as rare and uncommon in the State and include the Delmarva fox squirrel, (both Federal and State-listed as an endangered species), American beaver (S-3), marsh rice rat (S-3), and American mink (S-3). Three species ranked as (S-4) are secure in present habitat conditions are woodland vole, northern river otter, and star-nose mole. Four species are ranked as (SU), their status is uncertain but they are usually uncommon species believed to be of conservation concern, but data are inadequate to determine the degree of rarity. These SU species include the silver-haired bat, eastern red bat, and hoary bat. The remaining species are ranked as (S-5) common species and defined as secure in the State under present conditions.

Of the four exotic species found on the refuge, nutria causes the most concern. The only member of the family Myocastoridae, they are native to Brazil and Chile and were introduced in California in 1899 and during the 1930s in the Southeast. Nutria are denizens of freshwater or brackish marshes and compete for habitat

with muskrats. In the 1960s the annual take of nutria pelts (used mostly in trim and lining) and the meat (for pet food) was more than \$1 million.

Harvest and values of pelts declined drastically in the mid-1980s to early 1990s. The decreasing harvest resulted in concomitant increase in nutria damage to marsh habitats, levees, and agricultural crops. The first appearance of nutria on Prime Hook NWR marshes occurred in 1991. At the manager's request, a refuge trapper harvested any nutria encountered during the 1991 muskrat trapping season. A nutria was preserved as a museum sample for educational purposes at the refuge.

Adult nutria weigh about 26 kg (12 lbs) and eat about a quarter of their own weight in food per night. They are entirely vegetarian and generally prefer more common aquatic plants found in the habitats where they live. Nutria will also opportunistically feed on corn or other crops if adjacent to their marsh homes. Like muskrats, marsh plants are their favorite foods especially rushes, spikerush, pickerelweed, cattail, arrowhead, and smartweeds.

The presence of nutria on the refuge today is confirmed by anecdotal observations of animals seen along the peripheral edges of Units II and III marshes. However, nutria populations have not exploded or even significantly expanded on Prime Hook NWR since 1991. A nutria meeting was held at the refuge in February 2004 to assess the current status of Prime Hook NWR's nutria population, by Dan Murphy of the Maryland Nutria Project from the Chesapeake Bay Field Office and in attendance were Stephen Kendrot, the Nutria Project Field Supervisor, his staff, including trained nutria dogs, and several State DNREC employees.

In the past, refuge areas of confirmed nutria sightings were visited in an attempt to capture some animals. No nutria were found after 4 hours in the field. It was concluded that the present refuge wetland habitat management techniques (water level manipulations) have created insufficient habitat to support large numbers of nutria. Based on data from Blackwater NWR and other Delmarva areas with large populations, nutria are associated with large contiguous stands of *Scirpus*, which does not exist on Prime Hook NWR. In addition, the very shallow freshwater wetland systems readily freeze-up every winter, further stressing nutria and hampering proliferation.

In 2011, USDA Animal and Plant Health Inspection Service (APHIS) Wildlife Services conducted delimiting surveys to establish the distribution of nutria throughout the Delmarva Peninsula, focusing first on watersheds that have historically been occupied, even if only sporadically. Wildlife Services identified habitats and divided them into four zones. Prime Hook NWR was mapped in zone 3, identified as an area where nutria exist in small isolated populations; Wildlife Services habitat assessments prioritized zone 3 areas for more intensive ground searches. Twelve Wildlife Services personnel conducted nutria population delimiting surveys on the refuge from several boats in navigable waters along the shoreline edges. They also conducted ground surveys by foot in wetland and woodland habitats. Delimiting surveys were conducted from September 21 to 27, 2011 throughout the entire refuge; and no nutria were detected.

Refuge Endangered Species Management: Delmarva Fox Squirrel Population

The Delmarva Peninsula fox squirrel (*Sciurus niger cinereus*), generally called the Delmarva fox squirrel, was listed as federally endangered in 1967 because of concerns about a reduction in distribution to only 10 percent of its historic range.

The original recovery plan for the squirrel was approved in 1979 with a first revision in 1983. These plans emphasized two action objectives: identify optimum habitat conditions for the squirrel and translocate squirrels into suitable habitat outside currently occupied areas into new locations within their historical range.

The Delmarva fox squirrel was extirpated in Delaware in the 1800s. The recovery team decided to reintroduce fox squirrels throughout the Delmarva area and beyond. Sixteen translocations of Delmarva fox squirrels occurred from 1979 to 2000, including 11 in Maryland, 2 in Virginia, 2 in Delaware, and 1 in Pennsylvania. Delaware's sites were restricted to Sussex County; the first was a State wildlife management area (Assawoman) and the second site was on the refuge.

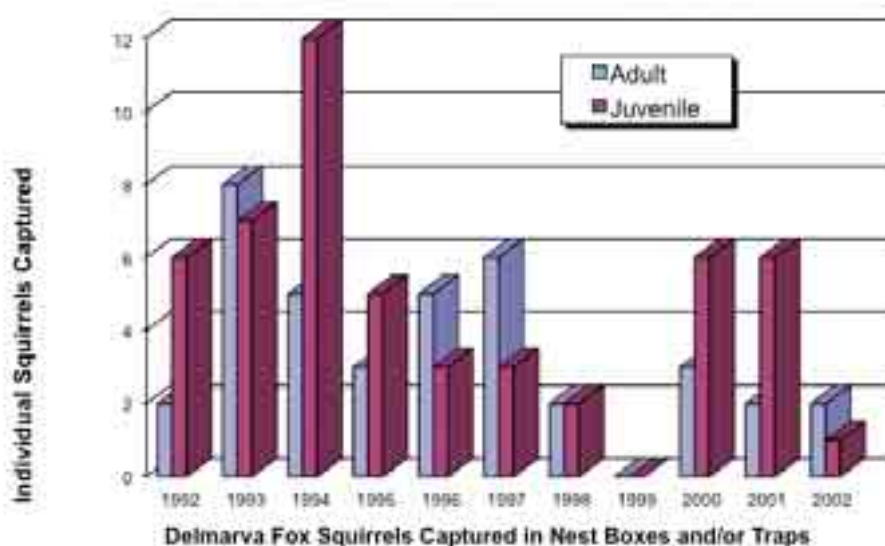
Prime Hook's translocations occurred in 1986 and 1987. A founder Delmarva fox squirrel population of 17 individuals, 4 from Dorchester County, Maryland, and the remainder from Blackwater NWR, was introduced onto the refuge. Two radio-collared squirrels were lost to predation during their first week on the refuge. The remaining squirrels settled into suitable forested habitats, mostly within Unit III.

By 1993, the Prime Hook translocations were deemed successful as per the 1993 second recovery plan, which defined success when a new reproductive population established on or near the original release site had persisted for at least 5 years and increased beyond the original group size (USFWS 1993). However, after 20 years the refuge population remains very small eliciting concerns of founder effects and genetic drift issues, and doubts about long-term viability of the refuge's population. Recent changes in land use surrounding the refuge (i.e., development), the small scale of available habitats on Prime Hook NWR and climate change and sea level rise modeling data, all suggest poor prospects for long-term viability and persistence for the refuge Delmarva fox squirrel population.

Moncrief and Dueser (2001) had recommended that a minimum of 30 squirrels would provide a sufficient number of founder individuals for reintroduced populations at specific sites to reflect enough variation present from a source population. More conservatively, Soule (1987) recommended a minimum of 50 individuals to avoid founder effects or decreased genetic diversity. The founding Prime Hook population may have been established at a disadvantage due to its small size ($n = 15$) from the beginning, which may warrant considering additional translocations of fox squirrels to augment the refuge population in the future.

Population monitoring and censusing is also more difficult on very small-sized populations. Annual nest box checks and live trapping efforts have provided some refuge trend data. Thirty nest boxes were established by the State of Delaware on Prime Hook NWR in the late 1980s for monitoring purposes. In 1992, the refuge added 45 more nest boxes for a total of 75 boxes, which samples an effective area of about 250 acres in 4 different locations. Calculating refuge fox squirrel population estimates based on traditional mark-recapture techniques for population size (Lincoln-Petersen Index) is imprecise due to small $\{n\}$ numbers and few recaptures. However, refuge monitoring data does provide evidence of annual recruitment for 10 of the 11 years monitored (figure 3-28).

Figure 3-28. Delmarva Fox Squirrel Nest Box Monitoring on Prime Hook NWR (1992 to 2002)



Refuge Delmarva fox squirrel population occurrence information from 2003 to present is based on sightings, trapping data, nest box checks and documentation from photo-monitors. In 2004, photomonitoring cameras were placed at 10 trap sites throughout the refuge in suitable squirrel habitat. During a 3-week sampling period, Delmarva fox squirrel visited five traps, four of which failed to capture squirrels. On May 26 and 30, 2004 two adult females were caught in traps and ear-tagged (H. Neiderriter, unpublished data). In 2005 and 2007, nest box checks resulted in zero squirrels captured and in 2008, photomonitoring efforts resulted in no observed or trapped fox squirrels. The long-term viability of the refuge's population is presently unknown (H. Neiderriter, personal communication).

Reptiles and Amphibians

A diversity of refuge natural communities provides for a variety of herpetofauna (38 species) on Prime Hook NWR. Common and scientific names for genus, species, and subspecies descriptions listed in this section are based on Crother et al. 2000. From 1999 to 2002, anuran (frog and toad) call surveys were conducted on selected tracts of Prime Hook NWR to assess overall quality and health of anuran habitats through time and to monitor the distribution of this sensitive group throughout Prime Hook. Twelve species were recorded from these surveys, of which one species is State listed – carpenter frog (S1).

Refuge Anuran Call Count Survey – Species Detected

American toad	<i>Bufo a. Americana</i>
Fowler's toad	<i>Bufo fowleri</i>
Eastern cricket frog	<i>Acris c. crepitans</i>
Green treefrog	<i>Hyla gratiosa</i>
Northern spring peeper	<i>Pseudacris c. crucifer</i>
Pickerel frog	<i>Rana palustris</i>
Northern gray treefrog	<i>Hyla versicolor</i>
Southern leopard frog	<i>Rana sphenoccephala utricularia</i>
Carpenter frog	<i>Rana virgatipes (S1)</i>
Wood frog	<i>Rana sylvatica</i>
New Jersey chorus frog	<i>Pseudacris feriarum kalmi</i>
American bullfrog	<i>Rana cateseiana</i>

The carpenter frog is found in freshwater wetland forest and emergent wetland ecosystems around the Prime Hook Creek drainage. It is a very rare amphibian species in Delaware and the refuge's population is only one of two in the State (Heckscher 2003).

Two local herpetologists have significantly contributed to the surveying, inventorying, and understanding of the refuge's herpetofauna. Joseph "Mick" McLaughlin began surveying anurans of the refuge from 1999 to 2002 by conducting anuran call surveys with the refuge biologist. He has been studying and monitoring the distribution of reptiles and amphibians in Delaware since the mid-1960s and continues critical work with the federally threatened/State endangered bog turtle, contributing much to the State's survey information. James F. White, Jr., herpetologist with the Delaware Nature Society, has conducted occupancy surveys and published several articles about Delaware's amphibians and reptiles. He conducted surveys on the refuge during the 2004 and 2005 field seasons, contracted by the Delaware Natural Heritage Program, as part of the refuge's CCP preplanning inventorying efforts.

State-identified reptile and amphibian species of greatest conservation need in Delaware (DWAP 2005) found on the refuge as a result of survey efforts include the following:

Tier 1

Carpenter frog
Cope's gray treefrog
Spotted turtle
Northern diamondback terrapin
Corn snake
Milk snake

Tier 2

Eastern spadefoot
Rough green snake
Eastern ribbon snake

Amphibians, which are a unique group of vertebrates with more than 6,000 known species, are threatened worldwide. A global amphibian assessment group (Stuart et al. 2004) has found that nearly one-third (32 percent) of the world's amphibian species, representing 1,856 species, are threatened. Amphibians have existed on earth for about 300 million years, but just in the past two decades nearly 168 species have gone extinct and at least 2,469 (43 percent) are declining in numbers as environmental threats continue to escalate.

Due to the especially high incidences of frog abnormalities reported in Minnesota and Vermont, the Service began assessments in region 5 (Northeast) and region 3 (Midwest) in 1997 to document the extent of abnormal frogs on refuges. Scientific literature suggests that abnormalities in amphibians occur normally at low frequencies (0 to 2 percent) in wild populations; therefore the Service set greater than or equal to 3 percent abnormality level as the trigger point for greater study effort (USFWS 2003a).

A malformed frog survey was conducted on Prime Hook NWR during the 1998 field season. The goal was to sample 50 to 100 frogs of the most abundant species. Two sites were sampled: Turkle Pond and Black Farm Pond. Turkle Pond proved to harbor too many amphibian predators which precluded catching a significant sample size (n=9). Black Farm Pond was ideal. One hundred twelve frogs were captured and examined, including 48 percent southern leopard frogs, 44 percent Eastern cricket frogs, 7 percent Fowler's toads, and 1 percent northern spring peeper (Williams 1998).

A low number (less than 2 percent) of cricket frogs were found missing eyes, which placed abnormality levels below the trigger point. Deformed tadpoles and frogs were also noted in the lead shot cleanup site, and remediation and future monitoring is addressing this frog issue on the refuge.

Invertebrate

Invertebrates are the most diverse and abundant animals in natural ecosystems, but their importance in sustaining those systems is not commonly understood or appreciated. Invertebrate conservation and management depends on sound knowledge of the distribution, biology, and food web dynamics of individual species and ecosystem interrelations which all have far-reaching implications for migratory bird management. E.O. Wilson (1987) elegantly referred to them as “the little things that run the world.” Both terrestrial and aquatic invertebrate communities are very important components within the Delmarva Coastal Plain ecosystem and more than outweigh all the taxa combined in species richness, abundance, and biomass.

Invertebrates serve vital functions as pollinators and detritivores (facilitating decomposition of matter and returning nutrients to the soil), and are critical food resources for birds, insectivorous mammals, fish, reptiles, and amphibians. They play predominant roles in all ecosystem processes and are necessary links in all food webs in refuge biological communities. Invertebrates represent critical elements of BIDEH and are essential to the maintenance of ecosystem services.

Invertebrate surveys for State-rare insects were conducted in 2004 and 2005. Insect surveys included numerous nights of blacklighting and baiting for nocturnal Lepidoptera (moths). In addition to nocturnal moths, fireflies, tiger beetles, and Odonata (damselflies and dragonflies) were also surveyed on Prime Hook NWR based on the high probability that the refuge harbors several uncommon species directly linked to a high diversity of habitat types. Diurnal Lepidoptera (butterflies and skippers) were also surveyed in 2005.

Of the animal inventories of refuge biological resources, insect surveys focused on species of conservation concern for which adequate information regarding conservation status (local, regional, global) are available. The objective of these invertebrate surveys was to complete an inventory of the refuge to reveal rare and uncommon species.

Thirty-one species of State conservation concern (S1, S2, SU, State records, county records, and new to science) were found during this sampling period, including 18 S1 species, 8 S2 species, 3 State records, 1 county record, and 2 new species unknown to science. All invertebrate species listed in the final report (McAvoy et al. 2007) are represented by voucher specimens that have been placed in the University of Delaware and/or DNHP insect collections.

The great purple hairstreak is an insect species of very high concern in Delaware (DWAP 2005). This butterfly’s host plant is mistletoe (*Phoradendron flavescens*); a large concentration of this parasitic plant occurs on the refuge. Adjacent fallow fields and open wetland areas where adult nectar plants occur, such as milkweed, several species of goldenrods, and buttonbush, provide important food resources for this and other lepidopteran species (McAvoy and Heckscher 2007).

Hydrangea sphinx was found in several locations throughout the refuge’s freshwater shrub and swamp communities; it is very rare across the Delaware landscape. The last confirmed State record prior to the refuge discovery in 2004 and 2005, was in 1886 (Heckscher 2003, Jones 1928). Host plants for this species are buttonbush (*Cephalanthus occidentalis*) and water willow (*Decodon verticillatus*).

Praeclara underwing populations were found in red maple/seaside alder along Prime Hook Creek coastal plain depression swamp, and coastal loblolly pine wetland forest. The host plant for this species is red chokeberry (*Aronia arbutifolia*). Due to its rarity in the State landscape Delaware Natural Heritage Program suggested making this species and its host plant a conservation target on the refuge. Red chokeberry is also a known host plant for *Catocala pretiosa*.

Although not found during 2004 and 2005 surveys on the refuge, if it is found in future years, its discovery would warrant consideration as an extremely high conservation target, as only a few secure populations are known worldwide (Heckscher 2003).

The rare marbled underwing was found in the swamp cottonwood coastal plain pond community, and considered highly notable by DNHP. It is State, regionally, and globally rare and an uncommon species in Delaware (S1, Tier 1, G3). The species was found with its suspected host plant swamp cottonwood (*Populus heterophylla*). This species is the largest underwing moth in eastern North America and is confirmed from only one other location in the State of Delaware. From a global perspective, the marbled underwing is the rarest animal species recorded by DNHP with the possible exception of State record firefly species (*Photuris pyralomimus*) and *Delphacid* species new to science, a plant hopper secured from the refuge's peat bog community currently being studied for taxonomic classification.

Mosquito Management on Refuge Wetlands

In the early 1900s, people became aware of the mosquito's role in disease transmission and recognized that controlling the mosquito would check diseases such as malaria. East coast tidal marshes were targeted for ditching as a means to drain marshes to control mosquitoes. From 1905 to the mid-1930s a general pattern of ditching known as parallel ditching was established. Ditches (greater than 36 inches) were run in a grid system, about 100 to 150 feet apart, across the surface of the marsh. This activity was carried out whether or not various marsh sites were heavy mosquito-breeding areas. Such drainage patterns resulted in the rapid removal of water from the marsh surface. Progress was evaluated in miles of ditches dug each year (Daiber 1986).

Parallel grid-ditching reached its peak during the depression years of the 1930s, when Federal and State agencies hired people to dig ditches by hand. Prior to Federal ownership, most of the refuge's marshes were parallel grid-ditched by Civilian Conservation Corps (CCC). CCC workers also widened the Prime Hook Creek that drained into the Broadkill Sound in 1933, near the current location of the second water control structure in Unit III (map 3-1).

Parallel grid-ditching was concerned only with the elimination of mosquito breeding with little to no consideration to other consequences. People with wildlife interests began to express concern about plants and animals associated with these drained marshes. This drainage technique significantly lowered the ground water table and replaced species of the low marsh zone (*Spartina alterniflora*) with less desirable species from the high marsh zone like salt marsh fleabane (*Pluchea odorata*) and salt marsh aster (*Aster subulatus*) followed by brushy vegetation particularly *Iva frutescens* and *Baccharis halimifolia* that invade dredged material piles. Lowered water table levels and shifts in vegetation become less desirable for waterfowl and other marsh birds due to the reduction in invertebrate populations as a food resource (Daiber 1986).

The Delaware Mosquito Control Section (DMCS), under Service permits, has controlled mosquitoes on the refuge since its establishment in 1963. The refuge has worked with the section to reduce the quantity of insecticides used on refuge lands and ensure activities are consistent with the Service's policies. Mosquito management is a complicated issue for the refuge. Prime Hook NWR is adjacent to residential beach communities where mosquito nuisance issues are amplified.

The control of mosquitoes is a State priority and a reality of management of salt marshes in the State of Delaware, and therefore, on the refuge as well. There are three techniques currently employed to control mosquito populations on the refuge within salt marsh habitats: use of the chemical adulticide, naled, source

reduction using the chemical larvicides, Bti and Methoprene, and biological control facilitated by open marsh water management.

Adulticides

Adulticides are inherently non-specific, i.e., they kill non-target species, as well as mosquitoes. The adulticides used on the refuge most recently include naled products such as Dibrom and Trumpet EC. Naled is a EPA Toxicity Class I (Highly Toxic) general-use pesticide, having the signal word “Danger” on the specimen label (Amvac 2005a). Based on acute toxicity data, the EPA considers the active ingredient naled, to be moderately to highly toxic to birds, moderately toxic to mammals, highly toxic to honey bees, moderately to very highly toxic to freshwater fish, and very highly toxic to freshwater aquatic invertebrates (EPA 2002). It is a fast-acting organophosphate adulticide licensed for the purpose of controlling aphids, mites, flies, and mosquitoes. Naled is a cholinesterase inhibitor; cholinesterase is an enzyme important for proper nervous system functioning in animals, including mammals, birds, fish, and other insects.

Larvicides

Like other varieties of the natural soil bacterium, *Bacillus thuringiensis* (Bt), *Bacillus thuringiensis israelensis* (Bti) is a stomach poison that must be ingested by the larval form of the insect in order to be effective (Exttoxnet 1996a). This soil bacterium contains crystalline structures containing protein endotoxins that are activated in the alkaline conditions of an insect's gut. These toxins attach to specific receptor sites on the gut wall and, when activated, destroy the lining of the gut and eventually kill the insect. The toxicity of Bt to an insect is directly related to the specificity of the toxin and the receptor sites. Without the proper receptor sites, the Bt will simply pass harmlessly through the insect's gut. Several varieties of Bt have been discovered and identified by the specificity of the endotoxins to certain insect orders. *Bacillus thuringiensis* var. *kurstaki*, for example, contains toxins that are specific to lepidopterans (butterflies and moths), while Bti is specific only to certain primitive dipterans (flies), particularly mosquitoes, black flies, and some chironomid midges. Bti is not known to be directly toxic to non-dipteran insects (Exttoxnet 1996a).

Methoprene is an EPA toxicity class IV general use pesticide, considered slightly to practically nontoxic (EPA 2001). Methoprene is a synthetic mimic of a naturally produced insect hormone, juvenile hormone (JH). All insects produce JH in the larval stages, with the highest levels occurring in the insect's early developmental stages. As an insect reaches its final stage of larval development, the level of JH is very low. This low level of JH triggers the development of adult characteristics. When an insect is exposed to methoprene, a hormonal imbalance in the development of the insect results, and it fails to properly mature into an adult. The insect eventually dies in the pupal stage. The most susceptible stages of development to methoprene are the later instars (for mosquitoes, third and fourth instars). In mosquito control applications, methoprene is applied to the larval breeding habitat. Methoprene is a non-specific contact insecticide that does not need to be ingested like Bti (Tomlin 1994). Larvae will continue to feed and may reach the pupal stage, but will not emerge as adults.

Due to the potential adverse effects of methoprene on non-target insects, Bti is the first chemical of choice for use on the refuge. However, the refuge recognizes that Bti exhibits limited efficacy under certain conditions; under those conditions methoprene would be the prudent alternative. Only formulations with short-term residuals (5 to 10 days) have been used for larval mosquito control. Use of methoprene products with long term residuals, such as Altosid XR-G, 30-Day Briquettes, or XR Briquettes, will not be permitted.

Mosquito control chemicals have been applied using handheld, backpack, and aerial dispersal methods. DMCS conducts surveillance and carry out methods, including dip samples, light/carbon dioxide traps, and landing rates. *Bacillus*

thurigiensis and methoprene are applied following limitations included in the product EPA label, an annual Service pesticide use proposal, and an annual refuge special use permit.

Areas Currently Permitted for Larvicide Treatments

In accordance with an annual larvicide special use permit, up to 8 larvicide applications per year (byground or air) can be made to any given marsh site, involving the following areas:

Unit I—no larviciding is allowed, but none was requested by the DMCS. Open Marsh Water Management (OMWM) work, was undertaken in Unit I in the 1990s with additional treatments in the early 2000s. Reduced saltmarsh mosquito production in this unit is low enough that the DMCS has had no need to request any larviciding in this unit for a decade or so.

Unit I—up to 1,637 acres within what use to be, until about 2009, a heavily-vegetated freshwater wetland impoundment (prior to recent bayfront breaching) can be larvicided. However, relatively little larviciding actually occurred in this unit during the past decade, due to its former freshwater impoundment habitat conditions having reduced saltmarsh mosquito production. The impounding of this unit did not eliminate all saltmarsh mosquito production, but it occurred in a more diffuse manner over widespread areas within the unit, that in aggregate can occasionally produce large numbers of adult mosquitoes.

Unit III—up to 2117 acres within what use to be until about 2009 a heavily-vegetated freshwater wetland impoundment (prior to recent bayfront breaching) can be larvicided. But for reasons similar to Unit II above, relatively little larviciding actually occurred within this unit for the past decade.

Unit IV—this unit received extensive OMWM treatment in the late 1980s and early 1990s, which greatly reduced saltmarsh mosquito production. DMCS is currently permitted to treat up to 371 acres that were missed by the original OMWM work, or which weren't mosquito production areas at the time of treatment, but have since naturally become such. Approximately 90 acres of formerly OMWM-treated areas are currently dysfunctional requiring maintenance, for a total of 461 acres that are currently permitted for larvicide treatments.

Areas Currently Permitted for Adulticide Treatments

In accordance with an annual adulticide special use permit, DMCS is currently permitted to aerially adulticide over a 600 ft wide strip of refuge lands immediately behind or landward of the 3 bayfront communities of Slaughter Beach, Prime Hook Beach, and Broadkill Beach, up to 6 times per year for any given site. The northern portion of this strip in Unit I, located behind the south end of Slaughter Beach, totals 58 acres; the southern portion of this strip in Units II, III and IV, located behind Prime Hook Beach and Broadkill Beach, totals an additional 169 acres, for a total of 227 acres.

Larvicide use on-refuge

From 2007 to 2011, aerial larvicide applications on-refuge (by fixed-wing aircraft or helicopter) averaged 1.2 applications per year (range = 0 to 3 applications), and involved an average total of 188 acres per year (range = 0 to 880 acres. Ground larvicide applications on-refuge (by hand or backpack sprayer) averaged 4.6 applications per year (range from 2 to 8 applications), and involved an average total of 11 acres per year (range = 5 to 19 acres).

Adulticide use on-refuge

Aerial adulticide applications on-refuge (by fixed-wing aircraft or helicopter) consistently averaged 1 application event per year over the 5-year period

examined (from 2007-2011), involving an average of 227 acres per application event (range = 55 to 227 acres).

Open Marsh Water Management

By the 1960s, a different form of water management for mosquito control advocated the use of biological control rather than mechanical drainage. This concept, which became known as quality ditching was fostered to replace parallel grid-ditching. Quality ditching has since been transformed into OMWM and is based on the following assumptions (Daiber 1986):

- Not all parts of a tidal marsh breed mosquitoes.
- Mosquitoes are greatly reduced or absent from portions of the marsh where tidal action circulates water over the surface and removes excess water.
- Biological control in the form of predation by marsh fishes will reduce mosquito populations.
- Permanent pools of water on the marsh surface serve as reservoirs for mosquito-eating fish, which can forage on the surface of the marsh among *Spartina alterniflora* stems during high tide cycles.

OMWM is a method for controlling salt marsh mosquitoes using physical alternations of marsh habitat. Ponds and ditches are selectively excavated in order to create unsuitable environs for mosquito production while creating suitable habitat for larvivorous fishes. This method is intended to mimic natural wetland features, such as pools and channels, more closely than the dense parallel grid-ditching techniques used in the 1930s. OMWM biological controls are effective in reducing mosquito production by 95 percent in treated areas (DNREC 2008).

In 1980 special use permits were issued to DNREC to start a refuge OMWM study that included a 6-acre control site and 6-acre treatment site in tidal salt marsh habitats in Unit IV. From 1982 to 1986 study data was collected and analyzed on the effectiveness of OMWM on the refuge to control mosquitoes. Four years later, a 90 to 99 percent reduction in mosquito production was recorded by the State in the treatment site and was deemed as a good technique to use to reduce the use of insecticides to control mosquitoes on the refuge, an environmental assessment was completed in 1987 to treat about 960 acres in Unit I and 430 acres in Unit IV salt marsh areas. In subsequent years other areas in Units II and III were identified as breeding areas where OMWM systems should be used. From 1989 through 1995, approximately 1,290 acres were treated with the construction of OMWM systems (closed ponds with sumps, radial ditches, plugs, and sills connecting existing parallel grid ditches), essentially removing about 1,800 acres from the spray program. In 2001, an additional 10.2 acres (3.2 acres of ponds and 7.0 acres of radial ditches) were treated with OMWM construction, removing an additional 362 acres from the spray program.

Socioeconomic Environment

Demographic data ranks Delaware's human population (830,364) as 45th in the Nation. State land area covers 1,982 square miles compared to 3,537,438 (U.S.), with a population density of 401 persons per square mile compared to 80 Nationwide. Delaware is 96 miles long and varies from 9 to 35 miles in width. Its chief products are manufacturing, mining, fish industry, and agriculture. Agriculture is one of Delaware's major industries, with 470,000 acres currently in croplands. Delaware ranks 5th in the Nation in percentage of land under cultivation, with a total of 39 percent of the total land cover in croplands.

Half of Delaware's 25 miles of seashore beach habitats are State parks. Prime Hook NWR is located in Sussex County 22 miles southeast of Dover. Refuge

Population and Demographic Characteristics

headquarters are located 12 miles southeast of the town of Milford and 10 miles northwest of the town of Lewes, both of which are also located in Sussex County.

Sussex County is somewhat less ethnically diverse than the State or Nation, with nearly 68 percent of its residents being white persons not of Hispanic origin (U.S. Census Bureau). The poverty rate in Sussex County in 2007 was 9.7 percent, lower than the rates for both the State and Nation. Median value of owner-occupied homes in Sussex County is \$220,100, which is higher than the national median home value of \$181,800 (American Community Survey). More than a quarter of all housing units in Sussex County are for seasonal or recreational use (American FactFinder, Census 2000 Summary File 1).

The largest town in Sussex County is Milford (population 7,201), part of which is in Kent County. Shipbuilding was the major industry of Milford through World War I. During much of the 20th century Milford served primarily as the commercial center for much of southern Delaware's large agricultural community.

Other large towns in Sussex County include Seaford (population 6,997), Georgetown (4,643), Lewes (2,932), Millsboro (2,360), and Milton (1,657). The primary industry in the area surrounding Seaford was agriculture, particularly the cultivation of tobacco, and the style of living was plantation. In 1925, the poultry industry became important as new methods of housing and feeding were introduced. The nature of farming changed from truck crops to grains and corn for chicken feed as Sussex County became the largest chicken-producing area in the world. In 1939, the DuPont Company chose Seaford as the site of the first nylon plant in the world (www.seafordde.com; accessed February 2012).

Georgetown is the county seat of Sussex County and contains the county's regional airport (Georgetown Local News 2006). The town is home to a large chicken processing plant owned by Perdue Farms. The plant employs a sizeable number of immigrants from Haiti and Guatemala. In fact, in 2000, 21.6 percent of Georgetown residents were of Guatemalan heritage, representing the highest percentage of Guatemalan Americans anywhere in the country (Georgetown Local News 2006) and giving Georgetown a more international feel than one would expect from a colonial-era town.

The Town of Lewes was founded as a Dutch whaling colony in 1631, giving it the distinction of being the first town in the first State, making Sussex County the oldest county in Delaware. Lewes is named after the town of Lewes in England, which also is situated in a county named Sussex (from which Sussex County, Delaware, takes its name), and has the same seal as its English counterpart. Lewes is a vacation and resort spot popular with residents of Washington, D.C. and the surrounding suburbs. Even though the city technically sits on the lower reach of the Delaware Bay, it is nonetheless considered an ocean resort, particularly as the ocean is nearby at Cape Henlopen. Lewes is the home of the Zwaanendael Museum, which features exhibits about Delaware's history. Fisherman's Wharf is a dock that stretches along the Lewes and Rehoboth Canal. It features multiple restaurants and bait shops, and in season the dock hosts hundreds of boats. The Lightship Overfalls, moored there, is owned by the Overfalls Maritime Museum Foundation and is one of seven surviving lightships at museums in the U.S.

The great mainstays of the local economy of Millsboro since the 18th century have been agriculture and timber, though both have changed significantly. Thriving businesses that began in the early 20th century include the manufacture of holly wreaths, cultivation of strawberry, and tomato canneries. Poultry production became a dominant industry in the Millsboro area, as in most other parts of Sussex County, beginning in the early 1930s (www.millsborochamber.com; accessed February 2012).

The Town of Milton, originally settled in 1672, is a quaint little Victorian shipbuilding village centered around the headwaters of the Broadkill River, that today it is a growing tourist attraction. For a small town, Milton has a remarkably large number of historic buildings and homes. It has a diversity of historic architecture and boasts 198 homes on the National Historic Register. Milton hosts several annual celebrations co-featuring Prime Hook NWR, most notably the Lower Sussex Bass Masters Youth Fishing Event and the Annual Horseshoe Crab and Shorebird Festival; the latter is a unique day of fun to raise awareness of horseshoe crab conservation and the critical link to healthy shorebird populations. The refuge also has a featured link on the Milton Chamber of Commerce home page.

Employment and Income

As the home to industry, agriculture, and numerous seaside resorts and small towns, Sussex County is diverse in both its natural resource assets and its lifestyles. The county is classified as a recreation and retirement destination, with an economy largely dependent on service industries. Tourism is responsible for employing more than 10,000 people in Sussex County with an estimated economic contribution exceeding \$709 million annually (Delaware Economic Development Office, 2008). Sussex County has abundant beaches and inland bays, beautiful state parks, and quaint historical towns. There are 16 public and private golf courses, with 2 additional courses currently under construction.

Today, western Sussex County is the center of Delaware's agricultural industry with more acres of land under cultivation than anywhere else in the State. There are 205 agricultural preservation districts now in Sussex County. Currently, Delaware leads the Nation in the percentage of protected farmland with 5.2 percent of the total land area and 11.3 percent in farms permanently preserved through agricultural easements.

Economic Benefits of Refuge Visitation and Management to Local Communities

National wildlife refuges enrich people's lives in many ways. Some benefits are relatively easy to quantify and some are not. Ecotourism is one method to derive economic benefits from the conservation of wildlife and habitats. It is important to quantify the economic effects of ecotourism to assist in refuge planning and facilitate the interaction of refuges and local communities (Caudill and Henderson 2005).

"In a world where money counts, the land needs value to give it a voice." —(Frances Cairncross/Banking on Nature 2004)

Economic impacts at the refuge have been evaluated through several analyses over the past several years. Caudill and Henderson (2005) evaluated the economic benefits of the refuge to local communities in 2004 through the Banking on Nature study discussed in this section. Sexton et al. (2007) reported visitor trip spending of non-consumptive visitors and big game hunters using 2004 to 2005 data as part of a visitor and community survey for the refuge (discussed in the "Community Attitudes and Opinions about Prime Hook NWR" section). Koontz (2010) provided regional economic impacts of current and proposed management alternatives for the refuge (appendix I).

Banking on Nature Study by Caudill and Henderson (2005)

Refuge visitors pay for recreation through entrance fees, lodging near the refuge, and purchases from local businesses for items to pursue their recreational experience. This spending generates economic activity throughout the local economy. Some of the money leaks out of the local area (leakage), and some is recycled through the local economy (multiplier). Spending by non-residents must be separated from spending by local refuge visitors. In the data below, total visitor spending is evaluated to show its significance to the local economy.

Daily visitor expenditures for both residents and non-residents were developed in four categories (food, lodging, transportation, and other expenses) for six activities: freshwater fishing, saltwater fishing, migratory bird hunting, small game hunting, big game hunting, and non-consumptive activities. Visitor days were factored in, and the total expenditures by category of spending for each activity were determined. The area economy of the local surrounding area was characterized by population growth, employment, and per capita income (Caudill and Henderson 2005).

Although Prime Hook NWR is located in Sussex County, New Castle and Kent Counties provide significant sources of numbers of refuge visitors. The area had a population of 818,200 in 2003, an increase of 15.8 percent from 1993, compared to a 12 percent increase Nationwide. Total area employment increased by 19.4 percent from 1993 to 2003 compared with an 18 percent increase in the U.S. per capita personal income increased in the area by 17.7 percent in the same timeframe. This compares with a 15.6 percent increase in the U.S (see table 3-16 for summary of these data: source from U.S. Department of Commerce 2003).

Table 3-16. Summary of Area Economy, 2003
(Population and Employment in thousands; Per Capita Income in 2004 dollars)

County	Population		Employment		Per Capita Income	
	2003	Percent change 1993-2003	2003	Percent change 1993-2003	2003	Percent change 1993-2003
New Castle	515.1	11.4%	342.1	16.4%	\$39,679	17.8%
Sussex	168.4	33.5%	85.9	29.5%	\$27,556	17.8%
Kent	134.6	14.1%	77.4	22.4%	\$27,152	17.4%
Area Total	818.2	15.8%	505.4	19.4%	\$35,123	17.7%
United States	290,789.0	11.9%	167,174.4	17.9%	\$32,322	15.6%

Prime Hook NWR had a total visitation of 106,525 during 2004 (table 3-17). The majority of recreation visits (108,611) were for non-consumptive activities and 63 percent of all recreational visits were undertaken by area residents.

Table 3-17. Prime Hook NWR 2004 Recreation Visits

Activity	Residents	Non-Residents	Total
Non-Consumptive:			
Nature Trails	30,077	20,052	50,129
Observation Platforms	5,264	3,509	8,773
Other Wildlife Observation	25,916	17,277	43,193
Beach /Water Use	0	0	0
Other Recreation	3,910	2,606	6,516
Hunting:			
Big Game	345	518	863
Small Game	71	4	75
Migratory Birds	1,100	367	1,466

Activity	Residents	Non-Residents	Total
Fishing:			
Freshwater	5,357	282	5,639
Saltwater	3,572	188	3,760
Total Visitation	75,612	44,802	120,414
Total Visitors			106,525

The regional area for the refuge is defined as Sussex, New Castle, and Kent counties of Delaware. In 2004, total Prime Hook NWR visitor recreation expenditures were \$1,043,600 with non-residents accounting for \$795,000 or 76 percent of the total refuge visitor recreational expenditures. Dollars spent by non-consumptive users totaled \$771,900, fishing expenditures accounted for \$222,100 or 21 percent of the total, and hunting expenditures (\$49,700) or 5 percent of total recreation expenditures (table 3-18).

Table 3-18. Prime Hook NWR: 2004 Visitor Recreation Expenditures (in thousands)

Activity	Residents	Non-Residents	Total
Non-Consumptive:	\$165.2	\$606.6	\$771.9
Hunting:			
Big Game	\$3.3	\$18.9	\$22.2
Small Game	\$0.3	—	\$0.3
Migratory Birds	\$7.5	\$19.7	\$27.2
Total Hunting	\$11.0	\$38.6	\$49.7
Fishing:			
Freshwater	\$36.2	\$100.6	\$136.9
Saltwater	\$36.1	\$49.1	\$85.2
Total Fishing	\$72.3	\$149.8	\$222.1
Total Expenditures	\$248.6	\$795.0	\$1,043.6

Table 3-19 quantifies the local economic effects associated with 2004 recreation visits. The data focuses on the final demand (see glossary), employment income, and tax revenue dollars generated by Prime Hook NWR's recreational visitors. In addition to the economic effects of refuge hunting and fishing programs to local economies, it measures the dollar impact of ecotourism, which is the recent phenomenon of large numbers of people traveling substantial distances to take part in non-consumptive uses of the natural environment, to capture the total economic impacts associated with refuge visitor spending.

This total final demand was calculated as \$1,456,000. This amount reflects the total monetary value of economic activity generated in the three county area by Prime Hook NWR visitor spending. In turn, the final demand generated 13 jobs (both full-time and part-time) with a total job income of \$419,400. Total tax revenue generated (county, State, and Federal) amounted to \$291,000 (table 3-19).

Table 3-19. Local Economic Effects Associated with 2004 Recreation Visits

	Residents	Non-Residents	Total
Final Demand	\$346,400	\$1,110,200	\$1,456,600
Jobs	3.0	9.8	12.8
Job Income	\$99,400	\$320,000	\$419,400
Total Tax Revenue	\$69,700	\$221,300	\$291,000

The total economic effects (total recreation expenditures plus net economic value) are compared with Prime Hook NWR's budget for 2004. Net economic value is defined as an individual's total willingness to pay for a particular recreation activity minus his or her actual expenditures for that activity. The figure for economic value is derived by multiplying net economic values for hunting, fishing, and non-consumptive recreation use (on a per day basis) by estimated refuge visitor days for that activity and combining that number with the estimate of total expenditures, and dividing by the refuge budget for 2004. Caudill and Henderson (2005) estimated that the total economic effect is \$1.85, meaning that for every \$1 of budget expenditures, \$1.85 of total economic effects are associated with these budget expenditures (table 3-20). This ratio provides a basis to compare the magnitude of economic effects resulting from refuge visitation to budget expenditures.

Table 3-20. Summary of Local Economic Effects of Recreation Visits (2004)

	FY 2004 Budget	Recreation Expenditures	Net Economic Value	Total economic effects per \$1 budget expenditure
Prime Hook NWR	\$1,290,700	\$1,043,600	\$1,344,400	\$1.85

Regional Economic Impacts of Current Management for the Refuge by Koontz (2010)

The USGS-Fort Collins Science Center estimated the direct and total economic impacts of refuge management activities in Sussex County. Refuge management activities of economic concern included refuge purchases of goods and services within the local community, refuge personnel salary spending, revenues generated by the refuge Revenue Sharing Program, and spending in the local community by refuge visitors. The economic impacts in this study were estimated using the impacts analysis for planning regional input-output modeling system. Refuge management activities directly related to refuge operations generate an estimated \$2.7 million in local output, 25 jobs, and \$742 thousand in labor income in the local economy. Including direct, indirect, and induced effects, refuge activities would generate total economic impacts of \$3.9 million in local output, 33 jobs and \$1.1 million in labor income.

More specifically, non-consumptive use directly related to refuge operations would generate an estimated \$2.1 million in local output, 21.3 jobs, and \$602.7 thousand in labor income in the local economy. Including direct, indirect, and induced effects, non-consumptive use would generate total economic impacts of \$3.1 million in local output, 29.3 jobs and \$875.6 thousand in labor income.

Fishing activities directly related to refuge operations would generate an estimated \$180.4 thousand in local output, 1.8 jobs, and \$50.4 thousand in labor income in the local economy. Including direct, indirect, and induced effects, fishing activities would generate total economic impacts of \$252.5 thousand in local output, 2.1 jobs, and \$72.1 thousand in labor income.

Overall hunting activities directly related to refuge operations would generate an estimated \$73.5 thousand in local output, 0.6 jobs, and \$21 thousand in labor income in the local economy. Including direct, indirect, and induced effects, overall refuge hunting activities would generate total economic impacts of \$103.5 thousand in local output, 0.9 jobs and \$30.1 thousand in labor income. A further breakdown of hunting activities on the refuge, including direct, indirect, and induced effects, reveals that big game hunting on the refuge would generate total economic impacts of \$45.5 thousand in local output, 0.4 jobs, and \$13 thousand in labor income. Waterfowl hunting on the refuge would generate total economic impacts of \$56 thousand in local output, 0.5 jobs, and \$16.6 thousand in labor income. Small game hunting on the refuge would generate total economic impacts of \$2.0 thousand in local output, 0.02 jobs, and \$500 in labor income.

Recreation and Tourism

According to the 2009 State of Delaware Comprehensive Outdoor Recreation Plan, 91 percent of Delaware residents indicate that outdoor recreation had some importance in their lives. When asked about facility needs, survey respondents in Sussex County identified as high priorities walking and jogging paths, bike paths, beach access, fishing access, and open space/passive recreation. According to the 2003 State of Delaware Comprehensive Outdoor Recreation Plan, the majority of Delaware residents surveyed think that there is too much development and not enough forests or open spaces in the State. Nearly half think there is too little farmland in the State, while one-third think there are too few wetlands in the State.

The National Survey of Fishing, Hunting, and Wildlife Associated Recreation collects information about anglers, hunters, and wildlife watchers in the U.S. (U.S. Fish and Wildlife Service and U.S. Census Bureau, 2006). The 2006 survey found that 395,000 Delaware residents and non-residents 16 years old and older participated in wildlife-associated recreation in Delaware. While the total number of participants¹ has fallen since 2001, the number of *days* spent participating in wildlife recreation has risen (table 3-21), as has expenditures on such recreation. In 2006, State residents and nonresidents spent \$299 million on wildlife recreation in Delaware, compared to \$148 million in 2001.

Table 3-21. Wildlife-Related Visitors in Delaware

Activity	Visitors (Resident and Non-Resident)		Visitor-Days (Resident and Non-Resident)		% Non-Resident Visitor-Days
	2001	2006	2001	2006	2006
Wildlife Viewing	232,000	285,000	722,000	855,000	16%
Fishing	148,000	159,000	1.4 million	1.8 million	33%
Hunting	16,000	30,000	226,000	654,000	22%

Source: U.S. Fish and Wildlife Service and U.S. Census Bureau (2006)

Wildlife Viewing

Abundant opportunities for wildlife viewing are available throughout Delaware. Wildlife viewing includes the activities of observing, identifying, and photographing. These activities can be done for formal educational purposes or general recreational enjoyment.

In 2006, trip-related and equipment-related expenditures associated with birding nationwide generated more than \$82 billion in total industry output, 671,000 jobs,

¹ The sum of anglers, hunters, and wildlife-watchers exceeds the total number of participants in wildlife-related recreation because many individuals engaged in more than one wildlife-related activity.

and \$11 billion in local, state, and Federal tax revenues, impacting local, state, and national economies (USFWS 2009a).

Wildlife-watchers spent \$131 million on wildlife-watching activities in Delaware in 2006 (U.S. Fish and Wildlife Service and U.S. Census Bureau, 2006). The majority (\$110 million, or 84 percent) of wildlife-watching expenditures were for equipment. Trip-related expenditures, including food, lodging, transportation, and other trip expenses such as equipment rental, made up \$13 million, or 10 percent of all wildlife-watching expenditures. Other items purchased by wildlife-watching participants, such as magazines, membership dues and contributions, land leasing and ownership, and plantings, made up the remainder.

Accounting for the multiplier effect of these direct expenditures, wildlife-viewing generated a total of \$203 million in economic activity and supported 1,975 jobs in Delaware in 2006 (Leonard 2008), comprising 0.34 percent of the State's Gross Domestic Product (Bureau of Economic Analysis) and 0.36 percent of all jobs in the State (USA Counties).

Preliminary findings from the 2011 National Survey of Fishing, Hunting, and Wildlife Associated Recreation report no significant change in wildlife watching from 2006 to 2011 and a nine percent increase from 2001 to 2011 in overall wildlife watching participation (U.S. Fish and Wildlife Service and U.S. Census Bureau, 2012).

Hunting

Total expenditures for all hunting activities Nationwide (big game, small game, migratory birds, and others) totaled \$22.9 billion in 2006 (USFWS and U.S. Dept. of Commerce 2006). A more detailed analysis conducted for waterfowl hunting Nationwide, found it generated over \$2.3 billion in total industry output, 27,618 jobs, and \$347 million in state and Federal tax revenues, impacting local, state, and national economies (USFWS 2008b).

Preliminary findings from the 2011 National Survey of Fishing, Hunting, and Wildlife Associated Recreation report that overall hunting participation has increased nine percent from 2006 to 2011 (U.S. Fish and Wildlife Service and U.S. Census Bureau, 2012). In 2006, hunting participation nationwide was decreasing; however, it was increasing in Delaware (U.S. Fish and Wildlife Service and U.S. Census Bureau, 2006). In 2006, the majority (57 percent) of hunting was for big game, with the remainder being for migratory birds (29 percent) and small game (14 percent) (U.S. Fish and Wildlife Service and U.S. Census Bureau, 2006). All hunting-related expenditures in Delaware totaled \$41 million in 2006 (U.S. Fish and Wildlife Service and U.S. Census Bureau, 2006). Equipment made up the largest proportion of hunting expenditures (\$25 million, or 60 percent). This was followed by trip-related expenses, such as food and lodging, transportation, and other trip expenses, which made up one-third of all hunting expenditures. The purchase of other items, such as magazines, membership dues, licenses, permits, and land leasing and ownership, made up the remainder of all hunting expenditures.

A more detailed analysis conducted for waterfowl hunting in Delaware, found it generated more than \$3.9 million in total industry output and \$679,000 in State and Federal tax revenues (USFWS 2008b).

Fishing

Total expenditures for all fishing activities nationwide totaled \$42 billion in 2006 (USFWS and U.S. Dept. of Commerce 2006). Preliminary findings from the 2011 National Survey of Fishing, Hunting, and Wildlife Associated Recreation report that the number of anglers increased eleven percent from 2006 (USFWS and U.S. Census Bureau 2012). In 2006, fishing participation Nationwide was decreasing, but it was increasing in Delaware (USFWS and U.S. Census Bureau 2006).

Fishing-related expenditures in Delaware totaled \$97 million in 2006 (USFWS and U.S. Census Bureau 2006). Trip-related expenditures, including food and lodging, transportation, and other trip expenses, totaled \$49 million—half of all fishing expenditures. This was followed by expenditures on equipment, which totaled \$39 million (41 percent of all fishing expenditures). The purchase of other items, such as magazines, membership dues, licenses, permits, stamps, and land leasing and ownership, made up the remaining 9 percent of expenditures.

Recreation in Sussex County

According to the 2007 Sussex County Visitor Profile Study (Delaware Economic Development Office, 2008), nearly 3.2 million visitors traveled to Sussex County in 2007, a 6 percent increase over 2006 and a 20 percent increase over 2005. The majority of trips to Sussex County were for leisure (78 percent), increasing nearly 2 percent over 2006. On the other hand, business travel to the County declined by 2 percent. After Delaware, most visitors came from Maryland and Pennsylvania. Personal auto travel remained the dominant form of transportation to Sussex County, accounting for 69 percent of person-trips in 2007.

The average age of visitors in to Sussex County in 2007 was 45 and the median income of households visiting Sussex County was over \$75,000, significantly higher than the median household income in Sussex County (\$50,132). Average total trip spending was \$405, a decrease of 7 percent from 2006. The average length of trip for Sussex County visitors was approximately 1.7 nights. Approximately 41 percent of overnight visitors stayed in a home/apartment/condo, while 30 percent stayed in a hotel/motel/resort and 19 percent stayed in a private home. Dining was the most popular activity for Sussex County visitors (42 percent), followed by visiting the beach/waterfront (41 percent), shopping (32 percent), entertainment (27 percent), touring/sightseeing (22 percent), hunting/fishing (13 percent), and visiting national/State Parks (10 percent).

Agriculture

As previously stated, Sussex County is the center of Delaware's agricultural industry. In 2007, 1.4 percent of all farmland in Sussex County was enrolled in Conservation Reserve, Wetlands Reserve, Farmable Wetlands, or Conservation Reserve Enhancement Programs.

According to the census of agriculture, farmland made up 41 percent of Delaware's land area in 2007. The majority of this farmland (81 percent) was used for growing crops, while 9 percent was woodland, 1.3 percent was pastureland, and the remaining was house lots, ponds, roads, and wasteland. In line with national trends, the average farm size in Delaware has been increasing, while total farmland has been decreasing. The average farm size in Delaware in 2007 was 235 acres, compared with the national average of 418 acres. Major crops grown in Sussex County are soybeans, corn for grain, wheat, barley, and corn for silage.

Community Attitudes and Opinions about Prime Hook NWR

USGS also estimated visitor trip spending and reported visitor and community attitudes and preferences about Prime Hook NWR (Sexton et al. 2007). The full report may be viewed at: <http://pubs.er.usgs.gov/usgspubs/ofr/ofr20071239>; accessed February 2012.

This extensive public use study was commissioned by the Northeast Region of the Service in support of the comprehensive conservation planning at Prime Hook NWR. The research was conducted by the Policy Analysis and Science Assistance Branch of the USGS/Fort Collins Science Center in order to determine how current and proposed CCP planning strategies for Prime Hook NWR could affect:

- Visitor use
- Visitor experiences

- Visitor spending
- Community residents' perceptions and opinions

Data for this study were collected using a survey administered to visitors to Prime Hook NWR and individuals living in the communities surrounding the refuge. 1,859 surveys were randomly distributed to two groups—to on-refuge visitors and to residents of surrounding communities, both consumptive (participating in fishing, hunting, or crabbing) and non-consumptive users. The stratified random sample of community residents, weighted with U.S. Census Bureau data to correct for age, gender, and community proportionality, had a ± 4.4 confidence interval and the visitor survey had a ± 5.4 confidence interval. Most refuge visitation is from repeat visitors, with visitors coming about 12 times a year and residents about 16 times per year. The study explicitly focused on whether there were statistically significant differences between the consumptive and non-consumptive users. About 72 percent of the total refuge visitors were from the local area and about half of them engaged in consumptive activities. Eighty-nine percent of the nonlocal visitors were classified as non-consumptive users. The non-consumptive users were more likely to be older (60s), retired, and female (54 percent). The consumptive users were more likely to be in their late 40s, employed, and male (97 percent). Other demographic factors were not significant differentiators between the visitor and community residents.

Wildlife observation was listed as the primary reason for both the visitor and community residents' visits, drawing 54 percent of the respondents' visits, regardless of whether they otherwise engaged in consumptive or non-consumptive activities. The refuge visitor group engaged in hunting more frequently than the community resident group and ranked it at a higher level of importance. The community residents more frequently participated in driving for pleasure and observing wildlife from or close to, their vehicles. The community residents also participated in various festivals, the National Fishing Day event, and organized lectures or birding trips to a larger extent than the refuge visitors did. Consumptive users primarily engaged in hunting (80 percent) and fishing (30 percent) and the non-consumptive visitors identified bird watching (73 percent), nature/wildlife viewing (64 percent), hiking/nature trails (56 percent), and special events, environmental education, and guided interpretive tours (collectively 68 percent) as their primary activities, although both groups did engage in the other activities. Proximity to the roads was of key importance to both the consumptive and non-consumptive users, but presumably for different reasons--the consumptive users use roads to access areas for hunting and fishing; many of the non-consumptive users, being older, remain in or near their cars while viewing birds on or near the water. However, non-consumptive visitors also placed the roads as important for viewing forest birds and paddling. Both the community residents and the visitors placed being in natural, undeveloped lands, experiencing a serene environment, using hiking/nature trails, and viewing birds on or near water as the activities of highest importance to them. Overwhelmingly, both consumptive and non-consumptive users held similar views of the refuge as providing attachment or meaning to their sense of place and identity and for family tradition or heritage.

Both groups expressed strong support for the level of services and features presently being provided by the refuge. In almost all categories of refuge services or opportunities, "Leave As Is" received the highest or close to the highest view (as compared to those wanting "More" or "Less" of some attribute.) Both consumptive and non-consumptive users indicated that refuge improvements could include increased wildlife viewing opportunities, improved environmental education and interpretive exhibits, increased hiking/nature trails, a new wildlife observation tower, and additional roadside pull-offs. Both consumptive and non-consumptive users highlighted only one area of services as important and poorly served by existing refuge management; this was media coverage/information, i.e., brochures and publications.

Local consumptive-use visitors rated the hunting and fishing programs as important and satisfactory, non-consumptive, especially non-local visitors, perceived the hunting programs as relatively unimportant and as “possible overkill” (a term not related to killing, but to the degree of program emphasis provided for that activity.) One statistical difference between the consumptive and non-consumptive users is that the non-consumptive users preferred to have more areas restored to natural conditions, more hiking trails, and more interpretive exhibits. When asked to rate five potential future services, the non-consumptive users rated an observation tower overlooking the marsh, road-side pull-offs, more walking trails around refuge headquarters, and more scheduled guided interpretive walks as far more important to them than the consumptive users rated such increased services. Non-consumptive users also wanted to have less hunting or level amounts of hunting, whereas the consumptive users overwhelmingly requested increased access for hunting and areas where they could set up their own blinds or deer stands.

Attitudes about certain aspects of visitor activities and refuge management revealed some areas of strong agreement amongst the respondents and some areas of clear polarization. Most habitat management options (restoration of natural habitats, use of fire to reduce risk and improve wildlife habitat, elimination of invasives) generated agreement amongst all respondents. The “continue farming/cease farming” issue was highly polarized when the survey was conducted in 2004 to 2005, with non-consumptive visitors far more supportive of restoration of natural habitats than the consumptive users. Continued land acquisition from willing sellers was strongly supported by both groups, of both private lands currently managed as farmland or of beachfront. Mosquito control generated strongly disparate opinions, again polarizing non-consumptive users who tended to favor limited spraying, but this group still accepted spraying when mosquito numbers are excessively high or when a public health emergency was declared. Since the survey was conducted before the breach of the barrier island east of Unit II, concerns about beach and marsh management did not generate public comments.

In contrast to the farming and mosquito control issues, hunting and other consumptive uses did not generate such disparities in attitudes between the non-consumptive users and the consumptive users. About 55 percent of the non-consumptive users were content to leave hunting ‘as is’ or to have it be increased. But the survey also included an open-ended response option regarding views about whether some activities should not be allowed/should be allowed on the refuge and about one quarter of the respondents provided some point of view. Some community residents stated the desire to have increased areas open for off-trail non-hunting use in addition to having more trails in areas now open to hunting. About 10 percent of the respondents expressed general opposition to hunting as an allowed refuge activity, but these comments did not reflect an understanding that hunting and fishing are identified by law as a priority public recreation wildlife-dependent use.

Spending associated with refuge recreational activities such as wildlife viewing and hunting can generate considerable tourism activity in the local Sussex County economy. On average, non-consumptive visitors spent 2 to 3 days in the local area with approximately three people in their group sharing expenses. Most of the non-local deer hunters were from other counties in Delaware; about half spent the night locally while the other half drove home after hunting. The current level of non-consumptive use and big game hunting non-local visitor days accounts for more than \$983,500 of spending annually in the local communities near Prime Hook NWR. Direct and secondary effects generate more than \$1.21 million in local output, \$447,700 in personal income, and 19.4 jobs annually in Sussex County.

Currently, there is no fee to visit Prime Hook NWR. Survey results indicate residents and visitors do not feel that they should have to nor would they be willing to pay to visit the refuge. Responses were divided among agreement, disagreement, and uncertainty regarding this issue, although visitors were more willing to pay a fee than community members. While opinions regarding fees sometimes change once implemented, more study would be needed if implementation of fees were to be considered at Prime Hook NWR in the future.

Respondents were asked about their participation in natural resource decision-making (civic engagement) and ways in which they commonly obtain information on these topics, as well as their level of trust in both the refuge and the Service. Understanding individuals' civic engagement and their trust in the managing organization aids in public communication efforts.

Visitors to Prime Hook NWR rely heavily on friends and neighbors for news and information about the refuge. Local residents rely mostly on newspapers, followed by friends and neighbors, for news and information about the refuge. There appears to be some emerging use of the Internet for refuge information by visitors and community residents. These results support the importance of targeting communication strategies and outlets to different user groups of the refuge to convey important messages.

Community residents and visitors to the refuge have been quite engaged in natural resource decision-making in the past 5 years, engaging in passive activities, such as signing a petition, and active activities, such as joining a special interest group. On average, visitors and community residents have engaged in half the activities listed in the survey. The most common activities include attending a public meeting (59 percent of visitors and half of community residents), signing a petition (59 percent of visitors and 45 percent of community residents), and joining a special interest group (about half of visitors and 41 percent of community residents).

Another factor important in public involvement in decision-making is trust in the managing agency. Visitors and community residents appear to have moderate trust in Prime Hook NWR staff and the Service. However, nearly a quarter are unsure about their level of trust in the Service and the refuge. A planning process such as development of the CCP is an opportunity to build relationships and improve trust not only with visitors and community residents with whom the refuge has established relationships, but also with those who are less familiar with the refuge or have not engaged in the process due to lack of trust in the agency or uncertainty of their role in the process.

The study has been a key tool for the Service as it developed the CCP and many of the actions and initiatives incorporated into alternative B reflect the perspectives expressed by the survey respondents, including increasing the extent of trails open both to consumptive and non-consumptive users, increasing habitat restoration efforts, and expanding environmental education and interpretation programs, informational brochures, internet information, etc. Some of the issues which were identified in 2004 to 2005 may be less confrontational now, such as increased recognition of the national policies about unacceptable farming practices (requiring use of non-genetically modified seed.) However, some issues which did not surface at the time of the survey, such as barrier island management and maintaining the fresh-water impoundments in light of climate change and sea level rise have generated controversy more recently. While many more non-local residents than local visitors did not engage in consumptive activities or felt that hunting should be reduced, slightly more than 50 percent of the non-consumptive users accepted hunting at existing levels or were supportive of an increase in this use. Only about 10 percent of the survey respondents felt that hunting should not be allowed at all, and it is possible that some of these visitors did not understand that Congress has already determined

that hunting and fishing are to be facilitated as well as wildlife observation, photography, or environmental education. Since hunting, fishing, and crabbing have been a key aspect of Delaware history and culture, the results of the random survey support the conclusion that the refuge has appropriately allocated its resources amongst all of its priority public recreation users, and that increasing opportunities for shared public access of areas which were previously closed to any public access will be perceived as beneficial by both consumptive and non-consumptive visitors.

Refuge Administration

Prime Hook NWR Staffing

Through the implementation of a regional workforce plan in 2007, Prime Hook NWR was merged with Bombay Hook NWR to form the Coastal Delaware NWR Complex. As part of the plan, some staff positions were deleted or reassigned to different positions. The approved staffing chart indicates five full-time employee equivalent positions (table 3-22).

Table 3-22. Prime Hook NWR Staffing levels (over the past 10 years)

Fiscal Year	FY 03	FY04	FY05	FY06	FY07	FY08	FY09	FY 10	FY11	FY12
Funded FTEs	9	8	8	8	7	7 (2 temps)	5 (1 temp)	5 (2 temps)	5 (2 temps)	5 (1 temp)
Approved FTEs	9	8	8	8	7	5	5	5	5	5

Facilities and Maintenance

A 3,920-square-foot headquarters building houses the refuge administrative staff. The building was constructed in 1997 and provides space for staff, a friends group sales outlet, public restrooms, and an auditorium that can accommodate 45 persons. Adjacent to the refuge office building is an office trailer that houses two employees. A larger building is needed to accommodate all staff in one building and increase auditorium seating capacity. Located in the headquarters area is a self-service boat ramp and a 12,350-square-foot parking area. The boat ramp provides access to Prime Hook Creek. There are two additional boat ramps on the refuge. In 2004, a 4,500-square-foot maintenance facility was constructed that allows for the storage and repair of refuge heavy equipment. The building has a full shop, which allows the maintenance staff to perform a wide range of tasks. A 3,200-square-foot pole style pavilion was constructed in 2006 to provide an area for festivals and educational programs to be held. In 2008, an additional pole shed was constructed to store equipment. The environmental education pavilion was replaced and relocated closer to the refuge office in 2010. Three county roads are found within the refuge. They are maintained by DelDOT.

The refuge has several informational kiosks, a photography blind, an accessible observation tower, and several hunting stands (96) and blinds (28) that are maintained for recreational uses. Walking trails cover a distance of approximately six miles. The refuge manages 4,200 acres of impounded marshes to provide feeding and resting areas for migrating birds, particularly waterfowl and shorebirds. Through a series of dikes and water control structures, the refuge controls water levels to manage for waterfowl and shorebirds. Three water control structures within the impoundments contain fish weirs. To access these areas and structures, there are paved, earthen, and graveled roads and parking areas.

Operating Budget

Table 3-23 summarizes the budget for the refuge over several recent years.

Table 3-23. Recent Refuge Budgets

	FY 04	FY 05	FY 06	FY 07	FY 08	FY 09	FY 10	FY11
Operation	370,527	609,678	216,845	301,956	318,489	697,093	320,397	295,722
Maint.	910,171	109,215	138,507	125,985	113,716	263,848	118,828	97,176
Visitor services	—	—	203,722	184,593	156,837	158,172	164,171	158,850
Planning	—	—	132,415	132,415		—		
Other	177,321	159,684	96,962	22,658	19,662	41,426	35,451	41,547

* Funds in “Other” category can be carried over from year to year; therefore, they do not necessarily represent new funds.

Refuge Visitor Services Program

A visitor services review of the refuge was conducted in October 2004 by regional office visitor services professionals to serve as a tool for refuge staff to use as they continue to develop their visitor services program and consider new possibilities in the various alternatives of the CCP (USFWS 2004a). A great deal of background information and recommendations from this review have been used to summarize the affected environment of the visitor services program at Prime Hook NWR.

Public use objectives at Prime Hook NWR are to provide wildlife-oriented recreational opportunities compatible with habitat and wildlife objectives. Current management at Prime Hook NWR provides for all six of the priority wildlife-dependent recreational opportunities, which are wildlife observation, wildlife photography, hunting, fishing, environmental education, and environmental interpretation. Long-term focus for the refuge, recommended in the review, suggests that emphasis should be placed on hunting, wildlife observation, and photography, and encourages the staff to continue to work toward providing and developing strong, high-quality programs in these areas in particular, and balancing the emphasis placed on these three uses.

The refuge’s affected audiences include hunters, anglers, birders, wildlife enthusiasts, photographers, beach tourists, and retirees. The refuge has dealt with a number of controversial issues over the years that have strained its relationship with the community. Past and current issues include land condemnation, management and protection of the endangered Delmarva fox squirrel, farming, hunting, dune overwash, lead shot contamination, and water management. However, refuge staff continues to work with diligence and patience to secure the community’s trust and understanding.

Service employees, volunteers, concessionaires, and other cooperators conform to the following standards when planning, conducting, and evaluating all visitor service activities and facilities at refuges, as described in Part 605 Wildlife Dependent Recreation of the Service Manual.

Visitor Services Plan

To date, visitor planning at Prime Hook NWR includes the public use management plan, which was prepared in June 1993. Currently, no updates or revisions have been made to the 1993 plan. In addition, the refuge has also prepared a sign plan (1992), a station management plan (1987), a safety plan (1986), a fishing plan (1986), a hunt plan (1987), a crowd control plan (1971), an occupant emergency plan (1983), a fire management plan (2003), a furbearer/trapping plan (1987), and an interim land use plan (1967). A visitor services plan is scheduled to be completed following the completion of the CCP.

Welcoming and Orienting Visitors

Eastern Sussex County, Delaware, is a major summer tourist attraction and receives several million visitors per year. A portion of those tourists visit Prime Hook NWR. Visitation at the refuge is growing as more people move into the area and as visitors traveling on Route 1 and 16 observe directional signing that clearly identifies the location of refuge headquarters. Increasing public use is expected to continue well into the future, bringing large numbers of first-time visitors in need of basic refuge orientation and information. Records going back to 1968 indicate a low of about 5,900 visits per year and a high of about 106,525 visits in 2004. Since 1995, the average number of visitors is approximately 81,000.

The visits at Prime Hook NWR fall into several seasonal categories. Throughout the year, visitors use Prime Hook by hunting, fishing, birding, canoeing/kayaking, wildlife photography and observation, and participating in environmental education programs, refuge special events, and interpretive programs. Summer visits primarily include tourists, education visits occur during the spring and fall, and outreach initiatives provide refuge information to visitors during the spring, summer, and fall through display booths at dozens of offsite events.

Refuge staff have not conducted formal surveys of annual visitation as limited funding and staffing along with numerous refuge access points have proved challenging. However, for the purpose of the CCP, annual visitation has been estimated based on a variety of sources, including a traffic counter located at the refuge headquarters area, hunt permits, visitor facility counts, group counts, and general observations by refuge personnel. Offsite interpretive exhibit numbers are based on either an estimate of total event attendance or the number of people visiting the refuge's exhibit.

During fiscal year 2012, over 85,000 people were estimated to have visited Prime Hook NWR. Onsite interpretation, special events, visitation at the headquarters office/visitor facility, nature observation, and photography accounted for majority of the visits; environmental education accounted for more than 400 visits; hunting visits numbered 1,520; fishing visits numbered 8,693; and other recreation accounted for an additional 1,929 visits.

The refuge has one primary access point at the refuge headquarters/visitor contact station located on Turkle Pond Road. There are four secondary entrances located at Slaughter Beach, Fowler Beach, Prime Hook, and Broadkill Beach Roads. These are State-maintained roads that cross the refuge and provide access to refuge lands and several beach communities.

The refuge headquarters entrance is the main entrance. A refuge orientation kiosk is located at the hunter check-in station located at the entrance to welcome visitors with refuge information and literature. The entrance sign is appropriately located outside the electronic gate entrance that provides access to the road leading to the refuge headquarters. There is one refuge entrance sign on the northeast tip of the refuge on the Slaughter Beach Road adjacent to the community of Slaughter Beach. The road here aligns with the refuge boundary. The entrance sign is suitably located where it is visible to visitors traveling in either direction along Slaughter Creek Road. Fowler Beach Road bisects the refuge, terminating at Fowler Beach. A refuge entrance sign is well-placed at the west end of the road and refuge entrance signs are located at both ends of this refuge-bisecting road. The entrance sign on the east end of the road is visible to visitors entering the refuge from the Prime Hook Beach community. The entrance sign located on the west end serves travelers who continue east on Prime Hook Road or who turn north onto Cods Road.

The refuge headquarters area is the key visitor activity location. By Service standards, the use of the word "center" implies more extensive visitor services

and facilities than currently exist here, which actually align more with the Service's concept of a visitor contact station. It was recommended by the review team that this location be identified as a visitor contact station or visitor facility.

The refuge does not charge an entrance fee; however, the Prime Hook NWR does participate in the Recreation Demonstration Fee Program through collection and deposit of hunting permit fees and boat launching fees. During fiscal year 2011, the refuge collected \$10,843 for hunt permits, with \$8,674 returned to the refuge. Boat launch fees and the sale of interagency passports yielded the refuge an additional \$656, with \$524 returned to the refuge. The review team commented that there did not seem to be a clear reason for charging boat launching fees while not charging fees for use of improvements such as boardwalk trails and observation platforms and recommended that the refuge explore developing a more equitable process for determining the imposition of user fees.

Information kiosks are located throughout Prime Hook NWR—at the headquarters, adjacent to all entrance signs except on Broadkill Beach Road, and near Slaughter Canal on Fowler Beach Road. Kiosks include flyers announcing upcoming refuge events and other information. Refuge orientation maps are included at some of the kiosks and would be a good addition to those kiosks currently lacking this map. Refuge volunteers regularly inspect and update kiosk information.

Wheelchair accessibility is available on trails, an observation platform, bathrooms, the visitor contact station and refuge office, fishing pier on Fleetwood Pond, and deer and duck hunting blinds. Benches are placed in several refuge locations, including the fishing access areas at Turtle and Fleetwood Ponds and along refuge hiking trails.

Refuge lands and outdoor facilities are open for public use half an hour before sunrise until half an hour after sunset. The refuge headquarters and visitor facility are open Monday to Friday, 7:30 a.m. to 4 p.m. The visitor facility is also open on weekends from 10 a.m. to 4 p.m. during April through November, and occasionally on weekends during the off-season. Staffing of the visitor facility is provided largely by refuge volunteers. It is sometimes difficult ensuring that volunteers are available, particularly on the weekends when safety concerns heighten with the absence of refuge staff. During open hours at the headquarters and visitor facility, the telephone is answered by a live person. The after-hours message on the answering machine offers facility schedules and emergency contact information. A general email address is posted on the refuge's Web site for visitors to inquire about Prime Hook NWR.

Additional information about welcoming and orienting visitors at the refuge can be found in the Prime Hook NWR Final CCP/EIS, Volume 1, chapter 3 (<http://www.fws.gov/northeast/planning/Prime%20Hook/finalccp.html>).

Hunting Opportunities

Prime Hook NWR hosts one of the largest hunting programs of all East Coast refuges within the Refuge System. Hunting is a historic, traditional, and very popular activity in the Prime Hook area and in other parts of the Delmarva Peninsula. Prime Hook NWR is open to hunting of deer, waterfowl, and upland game. The primary objectives of the refuge hunting program are to offer high-quality opportunities for hunting white-tailed deer, waterfowl, upland game, and webless migratory birds, and to manage wildlife populations, where appropriate. The two most popular forms of hunting at Prime Hook NWR are for waterfowl and white-tailed deer. During the 2011 to 2012 hunting season, 513 deer hunters and 908 duck hunters participated in refuge hunts, harvesting 66 deer and

1,050 waterfowl. Along with State hunting regulations, Prime Hook NWR has refuge-specific regulations at 50 C.F.R. § 32.27. Not all of these regulations are presented in this overview.

Section 605 (FW 1.10 F1) of the Service Manual states: “Refuge managers should offer wildlife-dependent recreation programs consistent with staff and funding resources needed to develop, operate, and implement the program safely and with quality standards.” The refuge’s existing hunting program is complex and requires a considerable amount of staff resources. The review (USFWS 2004) found our hunt program to be “out of balance with other priority refuge needs and services.” Another important quote from the review that confirmed the refuge staff’s own evaluation of the hunt program was, “the amount of station resources going into this activity (hunting) seem to far exceed what is necessary to provide for a quality hunting program.” The review also mentioned that the “care and maintenance of refuge blinds and tree stands....put an undue burden on staffing resources. Consideration should be given to eliminating this service, increasing the user fees for hunters, and either contracting this work out or hiring a temporary employee to conduct the maintenance.”

Administrative burdens of the existing program have included excessive compensatory time accumulations and staff burnout. The hunt program is out of balance with staff time used on other priority refuge needs and services, and the amount of station resources going into the program seem to far exceed what is necessary to provide for a quality hunting program. Administrative changes were made to the 2006 to 2007 program in collaboration with the Delaware Division of Fish and Wildlife to ease some of these administrative burdens on staff. These changes continued to be implemented during the 2011 to 2012 hunting season and included instituting self check-in procedures and hunter-facilitated morning drawings for blind and stand vacancies on lower use hunting days, and instituting a first-come, self-serve system for deer firearms hunts after the morning standby lottery drawings are conducted (this allows hunters to arrive throughout the day until 2 p.m. to check out any available stand; a similar procedure was already in place for waterfowl hunts).

To relieve staff from conducting the standby lottery drawings on the mornings of scheduled hunts, standby hunters were charged with the task of facilitating a drawing in the absence of staff on days other than opening hunt days. This system has proven to be reliable with few minor problems or complaints; however, the success of the program is dependent upon the hunters cooperating and monitoring each other, some staff monitoring, and law enforcement compliance checks. A few of the problems encountered with this system included failure of hunters to flip over their blind/stand tags, not following proper procedures for fee collection, and not properly filling out the permit information.

All hunters must possess a permit to lawfully hunt. Permits are issued by self-service for hunters wishing to pursue upland game, webless migratory birds, and deer by archery. Hunters wishing to pursue deer using firearms or waterfowl in refuge impoundments may participate in a daily standby lottery drawing for vacant stands or blinds on days open to hunting. On opening days, it is common for 80 or more waterfowl hunting parties (maximum of three people per party) to be present at the daily drawing for 26 blinds (including one handicapped-accessible blind), and more than 100 deer hunters trying for 89 stands (including 11 accessible blinds) when all hunting areas are open. Deer hunters may also enter into a preseason lottery drawing for stands. In 2011, nearly 700 applications were submitted for the preseason lottery drawing for deer stands. No preseason drawing currently exists for waterfowl hunting.

The issuance of permits through the daily lottery requires a staff member to be at the check station as early as 2:50 a.m. to check in pre-selected deer hunters or to sign-in waterfowl hunters for the lottery drawing. The current hunter facilitated drawings have decreased the number of days required by staff members to be present. Standby lottery drawings take place two hours before legal shooting time. Refuge staff operating the morning standby drawings consisted of an administrative assistant, visitor services manager, tractor operator, refuge manager, and deputy manager. After the morning standby lottery drawings, deer hunters may obtain permits by self-service until 2 p.m. and waterfowl hunters until 12 noon. All hunters must return their permits and harvest information to the hunt check station following their hunt.

Prior to implementing the administrative changes during the 2006 to 2007 hunting season, standby lottery drawings were conducted in 2004 by staff on a total of 49 days from October 2004 through January 2005. Stated another way, 40 percent of all the days from October through January required staff to be at the refuge early in the morning, therefore allowing them to leave for the day as early as 11:30 a.m., or stay and incur compensatory time to meet other required obligations. The program caused compensatory time accumulations of 90 hours or more, staff burnout, and inefficient use of management time to run the hunt. The total of 49 days breaks down into 13 deer days, which also included a daily stand-by drawing at noon for stand vacancies, and 36 waterfowl days. After the lottery drawing, vacant blinds for waterfowl hunting were issued on a first-come, self-serve basis until noon. There were also days when both deer and waterfowl hunting occurred, which required refuge staff to conduct two separate drawings each morning.

In past years, the refuge hired temporary positions to assist in conducting the daily drawings. From October through mid-December 2005, the check station was operated by a volunteer couple who were not from the local area. The use of temporary positions involves a considerable amount of training by refuge staff while not guaranteeing that the hired individual will remain throughout the hunting season before leaving for another position. Refuge staff has experienced the scenario in which the individual was just trained and left at the start of the hunting season. The use of local volunteers is not recommended, as it has led to accusations of special privileges and affected the integrity of the program.

The annual cost of conducting the 2004 to 2005 hunting program was approximately \$43,050. Hunter use fees accounted for estimated revenue of \$17,535, of which \$14,028 was returned to the refuge to offset the cost of the hunt. Still, the refuge recovered less than one-third the costs required to carry out its hunting program through the existing Recreation Demonstration Fee Program. After administrative changes were implemented, the cost of the 2011 to 2012 hunting season was \$34,482, which is \$8,568 less than during the 2004 to 2005 season. Hunter-use fees for the 2011 to 2012 hunting season accounted for an estimated revenue of \$10,973, of which \$8,778 was returned to the refuge. Expenses include planning, materials for stands/blinds, publications, hunt operations, law enforcement, processing applications, fuel/electricity, inquiries, and toilet rentals. All permit funds received from hunters are deposited into the fee account for use in supporting the hunting program and other visitor services related needs. Senior citizens (age 62 and older) are entitled to a 50 percent discount with an interagency senior passport. Citizens who have been medically determined to be permanently disabled are also entitled to a 50 percent discount with an interagency access passport. Refuge staff follow the guidelines of the interagency passport program. The interagency senior passport can be purchased in person for \$10 and the interagency access passport is free of charge at the refuge headquarters during office hours.

Refuge managers have taken reasonable steps to facilitate hunting through user fee programs and cooperative efforts. Refuge staff are very active in seeking and nurturing cooperative relationships with the Delaware Division of Fish and Wildlife and refuge volunteers. State personnel from the Assawoman State Wildlife Area work cooperatively with refuge staff to cut and grass the waterfowl hunting blinds located on refuge, on the Prime Hook Wildlife Area, and at the Assawoman Wildlife Area. In addition to our 17 blinds, we also administer the State's 8 blinds located in the Prime Hook Wildlife Area through the daily standby lottery drawing for waterfowl hunting. Besides conducting the daily lottery drawings, refuge staff, along with considerable assistance from volunteers, construct and maintain 115 combined deer and duck blinds, expending considerable human and financial capital. A small group of volunteers in 2011 donated over 500 hours in this area alone.

Deer Hunting Stands and Waterfowl Hunting Blinds

Permanent elevated deer hunting stands have been used on the refuge since 1983, when 20 stands were donated by the Delaware Division of Fish and Wildlife. By 1989, the use of these stands became mandatory. The majority of these stands were placed along the edges of agricultural fields of corn and soybean, which are attractive to deer. Since the cooperative farming program ceased in 2006, these fields have been maintained in early succession, which limits the ability of deer hunters to see and harvest deer from these permanent stands. Since 2006, refuge staff have been criticized for a decrease in the quality of their hunt because hunters are confined to these stands that do not offer any flexibility for movement. Relocating nearly 100 stands is not feasible due to lack of space within currently open areas, and time and budget restraints. Free roam areas for deer hunting are available to hunters in Unit I of the refuge, where hunters in groups of 2 to 10 can access four zones using boats (one is accessible by foot). Demand for these areas is low and the use of boats is a limiting factor. Free roam hunting of deer was permitted in all deer hunting areas between 9 a.m. and 3 p.m. up until the 2002 to 2003 hunting season, but was prohibited due to complaints of unethical hunting behaviour such as harvesting deer from the stands of other hunters.

Permanent waterfowl hunting blinds have been used on the refuge since the hunting program was first established in the 1960s. These structures are rectangular frames enclosed with plywood and mounted on a platform over refuge marshes. Every year, these blinds are camouflaged with switch grass. The variability from year to year in the vegetation surrounding these blinds may affect the naturalness or effectiveness of the camouflage. With current changes in marsh vegetation due to sea level rise and dune overwash issues, a majority of these blinds may be isolated in open water, minimizing their effectiveness. Hunters complain about the amount of grass on the blinds and current blind location, and many offer their preferences on how to improve the construction of the blinds to better meet their needs.

Both waterfowl and deer hunters have inquired about having greater flexibility to enhance the quality of their hunt by scouting, choosing their own hunting locations, and using portable hunting stands/blinds (boat blind, pop-up blind, tree climbers, etc.). For example, waterfowl hunters would like to have the flexibility to adjust their hunting locations for changing weather conditions. Waterfowl hunters have also stated that allowing them to camouflage themselves in the location of their choice will allow birds to get closer, thereby reducing crippling loss. Skybusting, or shooting at birds flying out of range, leads to more crippled birds and has been a constant complaint from refuge hunters.

Provision of elevated deer stands, and to a lesser degree waterfowl blinds, is relatively unique to Delaware. There are many areas on the Delmarva Peninsula,

other than Prime Hook NWR, that offer public hunting opportunities in free-roam areas where the hunter is required to provide the blind or stand, if desired.

The Service conducted a Web-search for public lands within the three states making up the Delmarva Peninsula in order that we evaluate the prevalence of permanent waterfowl blinds or deer stands on public hunting lands. A wide assortment of ownership and management regimes was evident across 215 tracts managed or described by 19 different designations, e.g., State Park, National Park Service, State Forest, Chesapeake Forest Lands, Natural Resources Management Area. For waterfowl hunting, 131 of the 215 tracts examined permitted waterfowl hunting. Of the 131, only 36 provided either a pit or standup blind somewhere on the tract. The Service makes this qualifying statement because some areas, Tuckahoe State Park for example, provide four pit blinds but also allow free roaming along the Tuckahoe River. Of the 36, 28 were located in Delaware, 8 in Maryland, and none in Virginia. Twenty tracts required hunters to hunt at a stake or within some designated distance from a blind site where the hunter would provide the blind (if desired), including 9 in Delaware, 11 in Maryland, and none in Virginia. A total of 84 tracts permitted free-roam hunting where the hunter would provide the blind (if desired), 17 in Delaware, 60 in Maryland, and 7 in Virginia.

For deer hunting, of the 215 tracts examined, 181 permitted some form of deer hunting. Unfortunately, the Service did not make a distinction between the various methods, i.e., some tracts may be limited to bow hunting only. Of the 181 tracts, 95 were located in Delaware, 77 in Maryland and 9 in Virginia. A total of 51 of the 181 tracts required hunters to use stands that were provided, all of which were located in Delaware. Free-roam hunting was permitted on 165 tracts, including 80 in Delaware, 76 in Maryland, and 9 in Virginia. The Service acknowledges that some free roam areas were for bow hunting only, however, such a distinction would only apply in Delaware; all deer hunting tracts in Maryland and Virginia permitted free-roam hunting regardless of hunting method.

For the 85 tracts located in Maryland and Virginia where no stands are provided, only 2 require an elevated stand, which the hunter must provide. For areas immediately adjacent to the building complex on Blackwater NWR, the hunter must use an assigned blind site where the hunter erects a stand with a platform minimum of 8 feet above the ground. All other tracts on Blackwater NWR are free-roam where ground-hunting is permitted.

The second site where elevated deer hunting is required is on Chincoteague NWR, around the tour loop. Here the hunter must erect his/her own stand with a platform minimum of 14 feet above the ground. All other areas on Chincoteague NWR permit free-roam hunting.

The Service should also add that rifle hunting, as well as deer drives, are permitted on most public hunting lands on the lower eastern shore of Maryland and the eastern shore of Virginia.

Refuge's Disabled Hunting Program

The refuge currently provides hunting opportunities for those individuals with a permanent disability as defined by the interagency access passport guidelines. However, up until the 2005 to 2006 hunting season, the refuge offered hunting areas with accessible ground blinds only for individuals permanently confined to wheelchairs to participate in a limited number of days for archery, firearms deer hunting, and waterfowl hunting. A disabled hunter who was not permanently confined to a wheelchair and who was denied access to these accessible blinds filed a complaint to the Washington, D.C. Office. As a result, the decision was made that refuges could not segregate individuals with certain disabilities from

others wanting to use the program's accessible sites, unless there is a justifiable reason established by the agency as a policy, which there is not.

Based on this decision, the refuge opened its wheelchair-only hunt area and structures to all individuals with any permanent disability and the disabled hunt area was required to remain open for all scheduled hunts on the refuge. The number of deer observed and harvested by hunters in this area decreased sharply when the change was made. Furthermore, the guidelines of the interagency access passport require refuge staff to rely on the honesty of the applicant and do not require medical proof of the disability. The Privacy Act prevents refuge staff from asking for proof of disability.

Since this change has been made, frustrations have been running high for staff and wheelchair-bound hunters. Hunters with wheelchairs have limited opportunities on the refuge to hunt unless refuge staff provide them with accessible infrastructure such as ground blinds and vehicular access to them. These hunters are limited by the accessibility that the refuge provides them.

Additional Information on Refuge Hunting Program

The refuge prepares one-page sheets or booklets on hunting information. These publications outline general provisions, permit information, and general requirements, such as hunting areas (including maps), seasons, shooting times, use of boats, youth and disabled hunting requirements, bag limits, safety requirements, stand/blind requirements, and other special conditions of the hunt.

Hunting areas and blinds are identified by numbered markers and referenced on hunting maps. Upland game hunting areas are not signed, but areas are referenced on hunting maps. Specifically designated parking areas are clearly identified on the refuge.

Use or possession of alcoholic beverages on hunt areas is prohibited. Youth must be accompanied by a hunting or non-hunting adult who is 18 years or older. It is recommended that the adult be licensed to hunt in the State of Delaware. Deer hunters are required to display a minimum of 400 total square inches of blaze orange material on their head, chest, and back. Deer hunters may only have loaded weapons while in their assigned deer stand or when actively in pursuit of a crippled deer. Designated safety zones have been established.

Hunting is a traditional activity in this area and little opposition has been encountered by refuge staff. Occasionally, adjacent neighbors complain about shooting noise and the close proximity of hunters to their property, particularly residents in the Broadkill area. Hunters must make a reasonable effort to recover wounded game and may not shoot toward the refuge boundary or into private property.

Most hunting occurs in areas of the refuge usually closed to the general public. During the 2 days each year that the headquarters area is open to deer hunting, it is closed to all other public uses. Impact of this closure on the visiting public is minimal. Canoeists and anglers are not permitted to launch at the office boat ramp to access the easternmost 3 miles of Prime Hook Creek from October 1 to March 15 to lessen disturbance to migrating and feeding waterfowl and potential conflicts with hunters. Earlier closures have also been necessary to accommodate the hunting of teal in September on the adjacent State-owned Prime Hook Wildlife Area and ensure the safety of refuge visitors. There are no commercial hunting guides operating on the refuge.

Certification of hunter safety education is a requirement to receive a State hunting license. The refuge has partnered with the State of Delaware to provide hunter education courses on the refuge, including the young waterfowlers course.

Hunting for White-Tailed Deer

During the 2011 to 2012 deer hunting season, Prime Hook NWR was open for 53 days of deer hunting from September 1 to January 28. The refuge was open for archery, muzzleloader, and shotgun hunting. Approximately 39 percent of refuge lands (4,020 acres) are available for deer hunting. Areas open to deer hunting are Prime Hook North, Prime Hook South, Fowlers North, Fowlers South, Cods Road, Jefferson-Lofland, Slaughter Canal, Island Farm, Headquarters, and Graves Tract (map 3-8).

The 2011 to 2012 deer hunting program resulted in a total harvest of 66 deer, which includes 26 (39.4 percent) male deer and 40 (60.6 percent) female deer. Deer harvested in 2011 to 2012 were not inspected by refuge personnel for weight and age. The State has eliminated deer checking stations, opting for local vendors to check deer for them. A youth hunt was conducted on November 5 with a total of nine young people removing four deer. In addition, disabled hunters made a total of 46 visits and harvested six deer. The refuge maintains 78 elevated deer stands, which include 32 for use in the headquarters area, primarily through volunteer assistance. An additional 11 wheelchair-accessible ground blinds are available to disabled hunters.

Deer hunters using firearms may enter into a preseason lottery drawing for stands. An application fee of \$3 is charged for each hunt for which a hunter applied. Currently there are six total hunts. Successful applicants may claim a permit for their stand reservation at the check station on the morning of the hunt. Successful participants in the standby lottery drawing for stand vacancies may also receive a permit. A daily fee per hunter of \$10 is charged for all firearm hunts and a daily fee per hunter of \$2 for all archery hunts. For archery hunting, hunters may obtain permits by self-service at the check station. In accordance with State regulations, hunters may take buck and antlerless deer – their license allows them to take two does and two antlerless deer. They may purchase a \$10 tag for an antlered buck and additional doe tags may be purchased for \$10 each. Only one buck may be taken on the refuge per hunter per year.

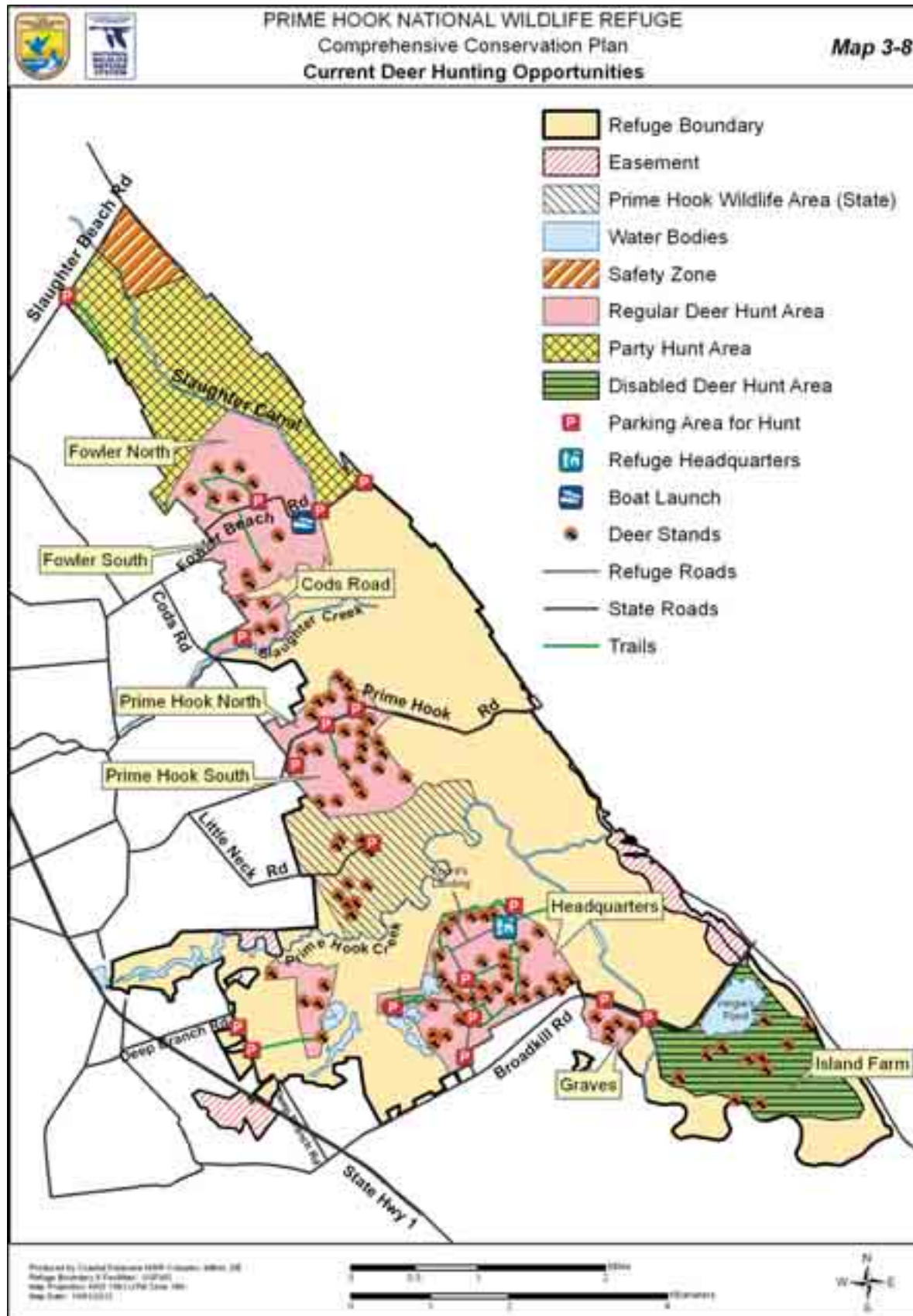
Except for the 2 days when the headquarters area is open to hunting, the refuge remains open to other users during the hunting season. Other than the headquarters area, hunting occurs in areas closed to other visitor uses. Scouting is permitted on Sundays from late August through late January. The refuge does not permit the use of dogs or off-road vehicles. No field trials are permitted and there are no shooting ranges open to the public on the refuge.

The Jefferson-Lofland Tract was closed to scouting and hunting in January to minimize disturbance to endangered Delmarva fox squirrel. Stands 9 and 10 in the headquarters area were closed during the late shotgun season to minimize disturbance to bald eagles. The headquarters area was not open during the statewide youth deer hunt to lessen administrative workload, reduce hunting pressure to maximize deer harvest during the hunt in November, and avoid conflict with adjacent landowners who are hunting waterfowl.

Deer hunters have been free roam hunting in Unit I of the refuge for years and upland game hunters free roam hunt in areas in Unit I, Unit II, and Unit III. Free roam hunting of deer was permitted in all deer hunting areas between 9 a.m. and 3 p.m. up until the 2002 to 2003 hunting season, but was prohibited due to complaints of unethical hunting behaviour such as harvesting deer from the stands of other hunters.

Upland Game and Webless Migratory Bird Hunting

During the 2011 to 2012 season, upland game hunting was permitted from September 1 to January 13, providing 80 total hunting days (this includes other migratory birds such as mourning doves). Squirrel hunting was closed



on the refuge due to lack of interest and to safeguard endangered Delmarva fox squirrel. Upland game hunting is permitted on 19 percent (1,995 acres) of refuge land at Prime Hook North and South, Fowlers North, and zones I to IV of Slaughter Canal; however, the southern portion of zone IV was closed to dove hunting. Although the refuge permits hunting of ring-necked pheasant, bobwhite quail, and woodcock, populations of these species are low in areas open to hunting and there is no hunter interest. Rabbits are most frequently hunted. A voluntary self-service permit process at the check station is used. In 2011 to 2012, 100 permits were issued resulting in 76 rabbits, one woodcock, and nine dove taken during 422 hours in the field. Interest in upland game hunting is limited due, in part, to the non-toxic shot requirement for small game. A fee of \$2 per hunter is required. Hunters obtain permits by self-service at the check station.

The refuge remains open to other users during the upland game and webless migratory bird hunting season. The use of dogs is permitted for flushing and retrieving small game. Hunters must make a reasonable effort to recover wounded game and may not shoot toward the refuge boundary or into private property. Prime Hook NWR is closed to upland and small game hunting during all firearms seasons for deer, except the handgun season for deer in early January and the antlerless season in October.

Waterfowl (Duck) Hunting

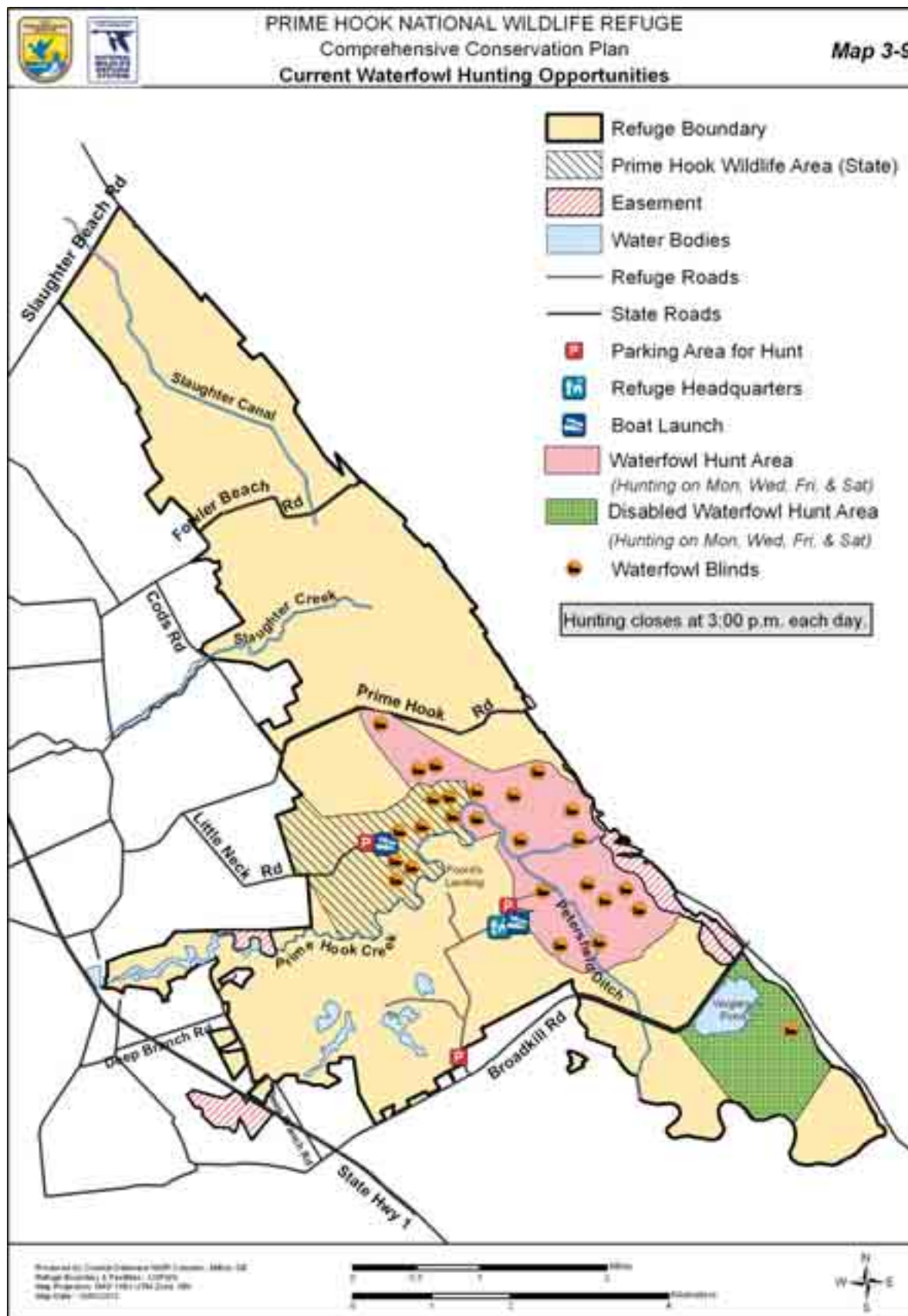
The 2011 to 2012 waterfowl hunting framework permitted Delaware a duck season of 78 days of hunting, including two additional days for a special youth waterfowl hunt. Delaware also offered a 64-day late snow geese season from February 1 to April 14, 2012. Prime Hook was open for a total of 41 days, which includes one of the Statewide youth waterfowl hunts. The refuge was closed for hunting of resident Canada geese and late season snow geese due to low hunter use and low harvest. Refuge staff facilitated the morning lottery drawing on January 14, 2012, for only the State blinds (refuge blinds were closed due to a deer hunt in the headquarters area). Hunting of snow geese was also permitted on the refuge during the duck season. A liberal bag limit of 15 snow geese per day was permitted. Hunting of migratory Canada Geese was permitted during the 2011 to 2012 season, with a daily bag limit of two.

A total of 25 marsh blinds and 1 wheelchair-accessible blind were available for hunting on Mondays, Wednesdays, Fridays, and Saturdays throughout the State duck hunting season. Refuge staff administered the morning standby lottery drawings on the first two opening days of all three seasonal splits. On all other days open to duck hunting on the refuge, including the youth waterfowl hunt, hunters facilitated the morning stand-by lottery drawings themselves. Hunting was permitted until 3 p.m. Overall hunter use for all hunts was slightly higher in 2011 (908) than in 2010 (874). In 2011, hunters harvested 1,050 birds; 1,604 birds were harvested in 2010.

The refuge remains open to other users during the waterfowl (duck) hunting season. The use of dogs is permitted for retrieving downed birds. Shooting outside an assigned blind is prohibited except in active pursuit of crippled waterfowl. The exception to this regulation is when hunting from a temporary blind in ponds 25 or 27. See map 3-9 for an illustration of the waterfowl hunting area.

The refuge is closed to resident Canada goose hunting in early September for the following reasons: low hunter use, low harvest, and the closure of Prime Hook Creek for hunting conflicts with other wildlife-dependent recreational opportunities involving canoers, kayakers, and fishermen on Prime Hook Creek. Since 2001, when the refuge began hunting for resident Canada geese, hunter visits and harvests have averaged 13 hunters and 9 birds a year. Only 3 to 4 days have been hunted each year. Managing this hunt involves closing the easternmost

Map 3-9. Current Waterfowl Hunting Opportunities



3 miles of Prime Hook Creek, which limits access for kayakers and fishermen for selected days during early September. The intermittent closure of Prime Hook Creek for a handful of hunters with minimal harvest numbers does not appear to warrant limiting access for fishermen and wildlife observers when this portion of the creek will be closed from October 1 (sometimes earlier) through March 15 for waterfowl hunting and to minimize disturbance. The intermittent closure of Prime Hook Creek for this hunting season also led to confusion among kayakers and fishermen and poses a safety risk for those who fail to see or read the temporary closure signs.

The refuge closed the late season snow goose hunting from late January to early March for the following reasons: low hunter use, low harvest, and no agricultural cover crops. Since 2001 when the refuge began hunting for late season snow geese, hunter visits and harvests have averaged 17 hunters and 16 birds a year. Eight days, on average, have been hunted. Hunters are permitted to sign out hunting zones (fields) and set up their own temporary hunting blinds. Since agricultural crops are not being planted, opportunities for upland snow goose hunting are very limited. With limited use and harvest during the season, continuing this hunt to provide opportunities for a few hunters does not appear to be warranted but will be continually evaluated. Opportunities to harvest snow geese are still available during the 35 days open to waterfowl hunting on the open marsh from October through January.

Turkey Hunting

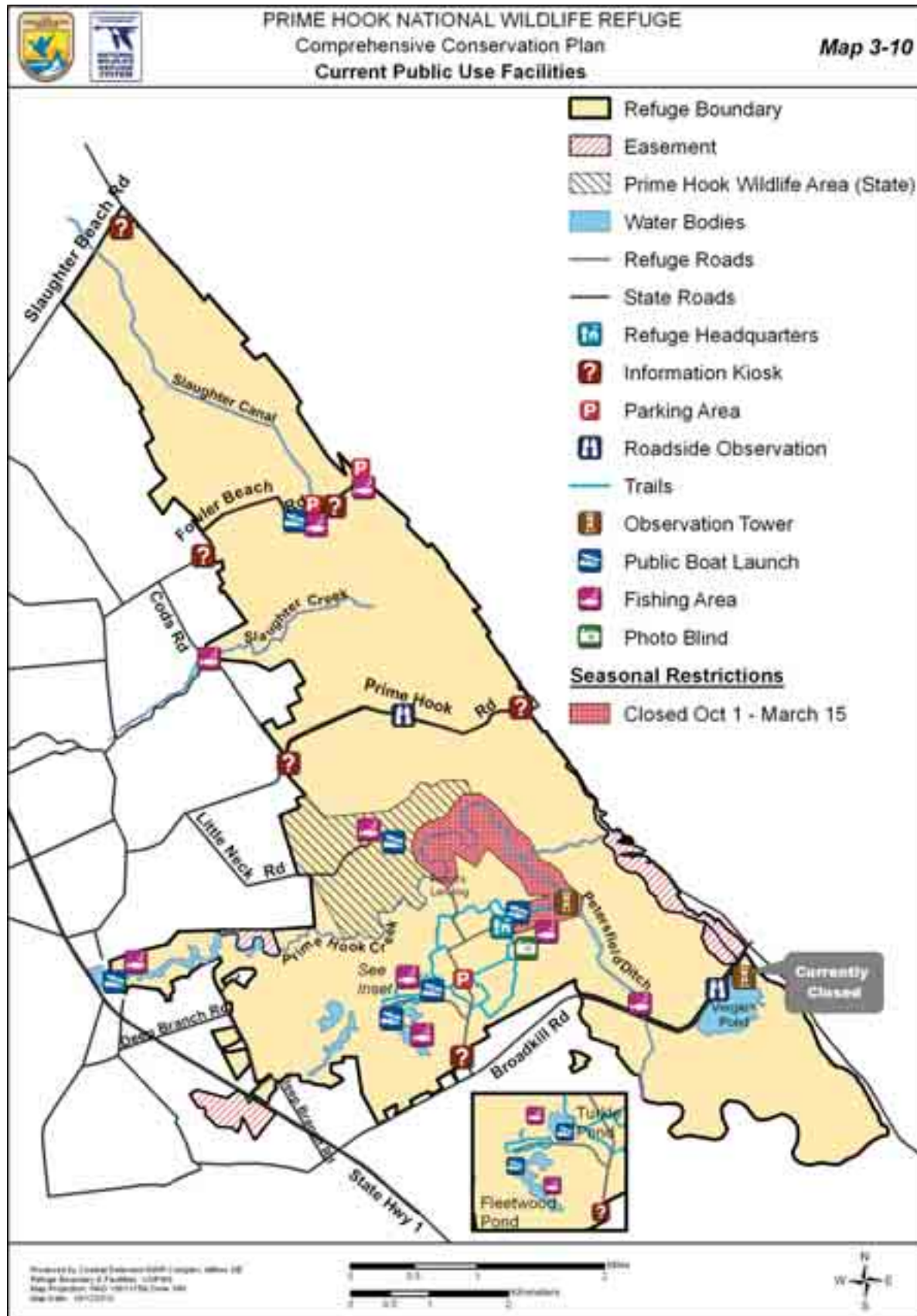
Turkey hunting was initiated on the refuge in 1993. After two seasons of hunting and only one harvested turkey, the opportunity was discontinued. In recent years, hunter and staff observations indicate that a huntable population of turkeys may exist on the refuge, particularly in the headquarters area and in areas near Deep Branch Road. Limited opportunities exist on public lands to hunt turkey and the refuge may be able to contribute in providing additional opportunities.

Fishing Opportunities

Freshwater fishing on Prime Hook is permitted along the Headquarters Canal in Prime Hook Creek, Turtle and Fleetwood Ponds, and Slaughter Creek at Cods Road (map 3-10). These freshwater marshes and ponds are popular fishing areas for largemouth bass, pickerel, white perch, crappie, and other species. Boats up to 30 horsepower are permitted in Prime Hook Creek and Slaughter Canal. Only electric or hand-propelled boats are permitted in Turtle and Fleetwood Ponds. Water control structures at Fowler Beach, Petersfield Ditch, and Slaughter Canal support brackish tidal waters that are popular for fishing for white perch and crabbing from shore. Bank fishing is restricted to designated areas off State maintained highways at these locations. Surf fishing at Fowler Beach along the Delaware Bay shoreline provides opportunities to catch estuarine species such as weakfish, striped bass, and flounder. During fiscal year 2012, the refuge estimates 8,693 fishing visits, including crabbing.

Signs that address fishing regulations can be found at the Headquarters Canal in Prime Hook Creek, Fleetwood Pond, and Turtle Pond. The signs outline refuge fishing regulations, ask visitors not to park on the boat ramp, identify October 1 (sometimes earlier) through March 15 as a time when access to Prime Hook Creek is by permit only, and direct visitors to gain access for canoeing and fishing from Waples Pond. There is a daily ramp fee to launch a boat from Turtle Pond, Fleetwood Pond, and the Headquarters Canal at a cost of \$1 per boat. The Prime Hook Wildlife Area also provides a boat launch into Prime Hook Creek. At Fowler Beach and Slaughter Creek, there are water control structures where crabbing and fishing are popular. An unimproved boat launch is located at the Fowler Beach water control structure site. A boat launch is located at both Turtle and Fleetwood Ponds and signs outline the fishing regulations and designate it as public fishing area. A refuge boat launch is also located at the

Map 3-10. Current Public Use Facilities



Brumbley Family Park; however, visitors must cross the Brumbley property to reach the refuge boat launch and the owner charges a \$4 fee per boat. No signs designate the area as a launch site, although refuge boundary signs are posted on each side of the ramp.

All roads, parking, and trails associated with the launch sites are fairly rustic except for the road and parking facilities associated with the Headquarters Canal ramp and dock. There is a ramp and a dock at the Headquarters Canal, and ramps located at Turkle Pond, Fleetwood Pond, the Prime Hook Wildlife Area, Slaughter Creek near Fowler Road, and Brumbley's Family Park. A wheelchair-accessible fishing pier is located on Fleetwood Pond. A boat ramp is located about midway on Prime Hook Creek at Foord's Landing and is closed to all public entry.

Prime Hook NWR has a one-page information sheet that highlights fishing areas, boating information, permits, boat launching, fishing hours, and special conditions for fishing on the refuge. In addition, the refuge includes a short passage in its general refuge brochure concerning fishing, canoeing, and boating. The refuge has also produced a brochure for its canoe trail that addresses certain launching sites available on the refuge. No fishing guides operate on the refuge.

Canoeists and anglers are not permitted to launch at the office boat ramp to access the easternmost 3 miles of Prime Hook Creek from October 1 (sometimes earlier) to March 15 to lessen disturbance to migrating and feeding waterfowl and lessen potential conflicts with hunters. Designated beach dunes and overwash areas are closed from March 1 through September 1 due to nesting State endangered least terns and American oystercatchers, and the potential for use by federally endangered piping plovers. Areas may be re-opened if no nesting activity occurs or when nesting ends for the season.

The refuge has partnered with the Lower Sussex Bass Masters in Milton to host a fishing event for kids the first Saturday in June. The event is held at the Milton Community Park and hosts 200 youngsters and their parents. The event includes fishing along the Broadkill River, exhibits, fish tanks, fish printing, and prizes to promote the recreation of fishing.

Wildlife Observation and Photography Opportunities

The refuge currently does not offer an auto tour route. Refuge staff recognize that an opportunity exists, but concerns about sign vandalism in remote areas of the refuge and the over-proliferation of interpretive signs were two reasons discouraging a signed route. Roadside vehicle pull-outs are located on Prime Hook Beach Road and along Broadkill Beach Road to provide increased opportunities for wildlife observation and photography along refuge impoundments.

Prime Hook NWR currently has approximately 6 miles of hiking trails, 7 miles of canoe trail, roadside pull-offs along State roads transecting the refuge, two observation platforms, one photography blind, two ponds, nine information kiosks, trailhead kiosks, a visitor contact station, five boat ramps, benches, and parking areas (map 3-10). The majority of the refuge's developed visitor use improvements are located near the refuge headquarters. A separate map of this area identifies the specific locations of each facility. An accessible wildlife observation platform is located on the Dike Trail, which overlooks a vast marsh and offers exceptional opportunities for wildlife viewing and photography. The Boardwalk Trail shares an entry off the headquarters parking lot and meanders through uplands and marsh. Both the Dike and Boardwalk Trails offer signs interpreting refuge habitats, wildlife, and history. The Black Farm Trail includes an extension to a photography blind overlooking a pond. Pine Grove Trail loops through a pine and hardwood forest habitat. The Blue Goose Trail serves

to connect the four existing trails and features upland fields, forest, marsh, and several wildlife observation areas. An uncompleted trail is located on the southside of Broadkill Beach Road overlooking Vergee's Pond.

The refuge offers at least 15 miles of canoe access, including the 7-mile brochure-interpreted Canoe Trail. Access to Canoe Trail and its associated marsh habitat is located on the east end near the refuge headquarters parking lot, at a mid-point in the Prime Hook Wildlife Area, and on the west end at the Brumbley Family Park. Canoeists and anglers are not permitted to launch at the office boat ramp to access the easternmost 3 miles of Prime Hook Creek from October 1 (sometimes earlier) to March 15 to lessen disturbance to migrating and feeding waterfowl and lessen potential conflicts with hunters. The review team (USFWS 2004a) agreed that serious consideration should be given to removing the boat ramp at the Brumbley Family Park, developing a special use permit for the landowner who benefits from charging for access, or exploring alternative sites for a ramp where the refuge would have more control.

Vital support from the refuge's Friends group has allowed the refuge to offer outstanding programs and special events. Since 2004, the refuge has hosted the Evening at the Hook Lecture Series on the second Thursday of each month. Topics focus on natural resource conservation, wildlife-dependent recreation, and cultural resources.

Also since 2004, the Vandegrift Memorial Series has been sponsored through an endowment received by the Friends of Prime Hook NWR. These lectures/performances take place once a year. A small fee is charged, typically less than \$10 per person. Previous events have featured the BBC film *Eggs on Coast*; Case Hicks, a Theodore Roosevelt impersonator; and Kiawani Lee, a Rachel Carson impersonator. These programs have taken place at off-refuge sites, including a local church and the Milton Theatre.

Prime Hook NWR offered its Fifth Annual Waterfowl Festival in 2006, and has seen attendance grow from around 50 in the first year to 1,200. The event included a very successful nature photography contest and featured live music, guided walks, fish and wildlife-related demonstrations, exhibits, food vendors, and a silent auction sponsored by the Friends of Prime Hook. It was made possible by the Friends of Prime Hook Refuge in partnership with the local tourism bureau, the town of Milton, local bass fishing clubs, State resource agencies, Ducks Unlimited, and the Delaware Department of Corrections. Due to reduced staffing at Prime Hook NWR, the refuge was forced to discontinue this popular event after 2006.

The Friends of Prime Hook NWR host a nature photography contest that illustrates the talents of local photographers, highlights the natural resources and scenery of the Delmarva Peninsula, and promotes the wildlife-dependent recreation of photography. Last year's event featured more than 300 entries from nearly 80 people. A reception is held to announce the contest winners and kick off a month-long exhibition of all photograph entries for visitors to enjoy.

Since 2004, Prime Hook NWR has partnered with the Town of Milton in the Annual Horseshoe Crab-Shorebird Festival in celebration of International Migratory Bird Day to offer special interpretive activities at the refuge and other activities in town. Refuge activities include guided canoe trips, bird walks, plant walks, pond seining, refuge tours, and field trips. This event has grown to 1,500 people.

Designated beach dunes and overwash areas are closed from March 1 through September 1 for nesting State endangered least terns and American oystercatchers, and the potential use by federally endangered piping plovers.

Areas may be reopened if no nesting activity occurs or when nesting ends for the season.

Environmental Education Program

Informing local students about nature, wildlife, habitat, the seasons of change, and how places like Prime Hook NWR play a role in their well-being has been ongoing for many years since the refuge's early beginnings. The refuge has in the past provided limited field trips to teachers by offering programs on requested topics, offered teacher workshops, and participated in programs such as the Sister Shorebird workshop. More recently, efforts have been made to align our efforts with the curricula in the local school districts and develop key partnerships that provide better opportunities for environmental education at Prime Hook NWR.

The refuge conducts environmental education programs as funding and staff time allow. The demand for programs from local schools, scouting, and other groups far exceeds our ability to provide them. We must rely on support from the Friends of Prime Hook NWR and volunteers to plan and implement these programs.

Currently, there are no facilities specifically designated for environmental education. The refuge currently uses the auditorium and small pavilion located near the refuge office for discussion areas and for field studies.

Over the past several years, refuge staff and the Friends of Prime Hook NWR have been working to develop an environmental education program to better meet the needs of both the refuge and the local school districts (Cape Henlopen and Milford). The Friends of Prime Hook NWR have taken an active role in its development, creating an environmental education committee. Refuge staff and the education committee partnered with the science coalition specialist at Cape Henlopen School District to develop an insect program for second grade students, which has been very successful since 2005. The partnership started with the topic of insects, something tangible and familiar to students and the volunteers leading the groups. In 2008, a watersheds program was developed for seventh grade students through the assistance of a grant by MBNA. The refuge is currently planning a birding program.

Teacher workshops have been offered in the past but without success due to time restraints on the teachers. Refuge staff and volunteers occasionally go to schools to provide programs to classes of various age groups. Based on the definition of environmental education, which identifies any environmental education program as one that addresses a class's academic standards, the review (USFWS 2004a) concluded that most of the offsite school programs may fall into the category of environmental interpretation.

Current evaluation methods include up-front evaluation (coordinating with the field trip leader on what is expected of the trip) and informal follow up with teachers, students, and chaperones.

Interpretation of Key Resources and Issues

Key resource topics or interpretive themes of Prime Hook NWR focus on the awareness and importance of the conservation of waterfowl and other migratory birds, the endangered Delmarva Peninsula fox squirrel and other threatened or endangered species, and their associated habitats. No specific interpretive themes or messages have been developed at this time. Currently, key issues affecting the refuge are climate change/sea level rise, mosquito control, the cooperative farming program, and the beach overwash/Fowler Beach Road repair issue.

Personal services interpretation includes guided birding trips, a monthly lecture series, an annual Vandegrift Memorial Lecture, and an annual nature photography contest. The refuge also partners with the Milton Chamber of Commerce to co-host the annual Horseshoe Crab-Shorebird Festival and with the Lower Sussex Bassmasters to promote youth fishing.

The refuge headquarters building includes a small visitor information area. The visitor information area includes an information desk and sales area, display cases, and a 45-person multi-purpose room that is used for special exhibits, training, and special programs.

The refuge has a large number of brochures and handouts available to the public. Some of the materials are refuge-specific, some specific to the local area, and some are generic to the Service. Information is provided to orient refuge visitors and educate them about refuge resources and regulations.

Traveling or portable exhibits have been developed for the refuge that highlight habitat management, wildlife, public use opportunities, volunteers, and the friends group. These exhibits are used at several local events to provide information about the refuge to participants.

The refuge maintains an audio/visual library, including a professionally produced 12 minute video that highlights Prime Hook. Self-guided interpretive facilities and materials, including signs, maps, and kiosks, are available for the Blue Goose Trail, Photography Blind Trail, Dike Trail, Black Farm Trail, Pine Grove Trail, Boardwalk Trail, and Canoe Trail.

Current compatible uses on the refuge include sport fishing; commercial fishing; commercial trapping of muskrat, raccoon, etc.; turtle trapping; public hunting of waterfowl; public hunting of other migratory birds; public hunting of big game-turkey; public hunting of big game-deer; public hunting of upland game; environmental education; canoeing; walking, hiking, and jogging; wildlife/wildlands observation; photography, picnicking; 5k road race; research; special use permit of the Federal Aviation Administration VORTAC tower; beekeeping; waterfowl retrieval permits; and mosquito control.

All commercial and economic uses will adhere to 50 CFR, Subpart A, §29.1 and Service policy which allow these activities if they are necessary to achieve the Refuge System's mission, or refuge purposes and goals. Allowing these activities also requires the Service to determine appropriateness and prepare a compatibility determination and an annual special use permit outlining terms, conditions, fees, and any other stipulations to ensure compatibility.

Communicating Key Issues with Offsite Audiences

Key resource topics or interpretive themes of Prime Hook NWR focus on the awareness and importance of the conservation of waterfowl and other migratory birds, endangered Delmarva Peninsula fox squirrel and other threatened or endangered species, and their associated habitats. Currently, key issues affecting the refuge are climate change and sea level rise, mosquito control, the cooperative farming program, and the beach overwash/Fowler Beach Road repair issue.

The refuge's affected audiences include hunters, anglers, birders, wildlife enthusiasts, photographers, beach tourists, and retirees. The refuge has dealt with a number of controversial issues over the years that have strained its relationship with the community; however, refuge staff continue to work with diligence and patience to secure the community's trust and understanding.

Public comments have been collected during public scoping meetings and from visitor and community surveys through planning efforts for the CCP.

Volunteer Programs and Partnerships with Friends Organizations

The proposed alternatives in the CCP will provide the public with a future management direction for the refuge, and additional public meetings will provide greater opportunities to communicate and gather public opinion.

Approximately 100 active volunteers participate in a range of services and activities in the areas described below:

Visitor Contact Station: training and mentoring; greeting and informing visitors; answering telephone inquiries; sales outlet ordering; stocking brochures; miscellaneous clerical and office projects; and miscellaneous administration duties.

Biological: horseshoe crab sampling; weekly bird surveys; water level readings and management; shorebird and osprey banding; volunteer bluebird nest box monitoring program; constructing and placing monitoring boxes for the endangered Delmarva Fox Squirrel; and vegetation transects and surveys.

Maintenance: trail maintenance; equipment maintenance; maintenance, repair, and construction of deer stands and duck blinds; designing and installing directional signs for deer stands and duck blinds; designing and constructing trails; building construction; building and installing information kiosks; volunteer patrol for litter cleanup and providing refuge information to visitors; mowing grass and assisting with herbicide spraying; changing and installing boundary signs; landscaping around refuge office; assisting with Department of Correction crews; repairing gates; routine office building cleaning; washing vehicles; and miscellaneous office repairs.

Public Use: planning, organizing, and staffing annual Horseshoe Crab-Shorebird Festival and annual nature photography contest; organizing the annual Vandegrift Memorial Series; maintaining databases on newspaper clippings; planning and implementing environmental education programs; designing and maintaining friends group newsletter; conducting birding field trips; holding monthly lecture series and supplying refreshments; completing and submitting monthly reports; conducting tours for groups; staffing information booths at local events; promoting fishing to children at the Lower Sussex Bass Masters Annual Youth Fishing Event; distributing visitor use surveys for the CCP; updating the friends group Web site; designing and coordinating a refuge library of reference materials; applying for miscellaneous grants; maintaining a database; and organizing and coordinating other volunteers.

Volunteers are managed in a three-tier system. The refuge's visitor services manager serves as the station's volunteer coordinator. A volunteer serves as assistant volunteer coordinator, screening potential applicants and assisting the manager with the administrative aspects of the program. Several other volunteers coordinate specific activities such as trail maintenance, outreach, landscaping, etc. The visitor services manager receives feedback from staff and volunteers on work performance.

Over the past several years, Prime Hook NWR has developed a partnership with the Georgetown facility of the Delaware Department of Correction, which supplies a volunteer prison work crew to the refuge throughout the year. In prior years, the typical 13-person crew visited the refuge on a weekly basis; more than 16,000 hours of maintenance-related work has been provided to the refuge since 2003. Projects have included removing deer stands, rebuilding duck blinds, facility maintenance, mowing, carpentry, painting, and more.

Volunteer contributions have increased considerably over the last several years, from 2,257 hours in 1998 to a high of 11,963 hours in 2006. In fiscal year 2012, 103 volunteers contributed 6,487 hours. Refuge staff praise and thank volunteers for their work. During conversations with refuge volunteers, the review team

stated that it was very clear the volunteers felt appreciated by the refuge staff. The refuge also organizes two volunteer recognition and appreciation events each year. In late summer, the refuge hosts a volunteer barbeque and in late winter or early spring, a volunteer recognition event. Due to large numbers, the refuge rents the Milton Fire Hall for the latter event which includes a formal recognition ceremony and catered dinner.

Volunteer gifts are distributed at the recognition event. A program was established to award volunteers with recognition items such as pins, patches, coffee mugs, etc., based on their cumulative hours. The refuge staff also recognize volunteers who provide considerable hours during the calendar year, including the prestigious “Blue Goose Award” for the volunteer with the highest amount of hours. This is a wooden sandblasted plaque with a painted blue goose and engraved plate.

Prime Hook NWR has developed informal partnerships with a number of community organizations and State agencies including: Lower Sussex Bass Masters; Retired Seniors Volunteer Program; Town of Milton; Chambers of Commerce in the towns of Milton, Lewes and Milford; Southern Delaware Tourism; Delaware Department of Corrections; Sussex Bird Club; Ducks Unlimited; USGS; Delaware Division of Fish and Wildlife; DNHP; local Boy Scout troops; Milton Development Corporation; Milton Theatre; Cape Gazette; Delaware Forest Service; M.R. Designs, Inc; Centex Home Builders; Delaware Division of Parks and Recreation; University of Delaware; and many more.

The Friends of Prime Hook NWR, a 150-member non-profit grassroots membership organization, supports the refuge in many ways. The Friends operate a bookstore and gift shop, serve as refuge volunteers, enhance public use opportunities, provide public outreach for the refuge, seek out and apply for grant opportunities, and much more. This group has been instrumental in supporting the visitor services program by leading guided walks, establishing an environmental education committee to assist the refuge in the developing an environmental education program, sponsoring the Vandegrift Lecture Series and nature photography contest, and assisting with the refuge’s various special events. They coordinate the refuge offsite exhibits at local festivals and promote refuge messages to the community.

The Friends of Prime Hook NWR function as the cooperating association of the refuge, managing a gift shop at the refuge’s visitor facility. Sales items include natural resource-related products such as t-shirts, stuffed animals, jewelry, and books. The gift shop is open weekdays from

7:30 a.m. to 4 p.m., weekends from April through November from 10 a.m. to 4 p.m., and occasionally on weekends during the off-season. The refuge has no concessionaires at this time.



Delmarva fox squirrel

USFWS